Electrical Engineering

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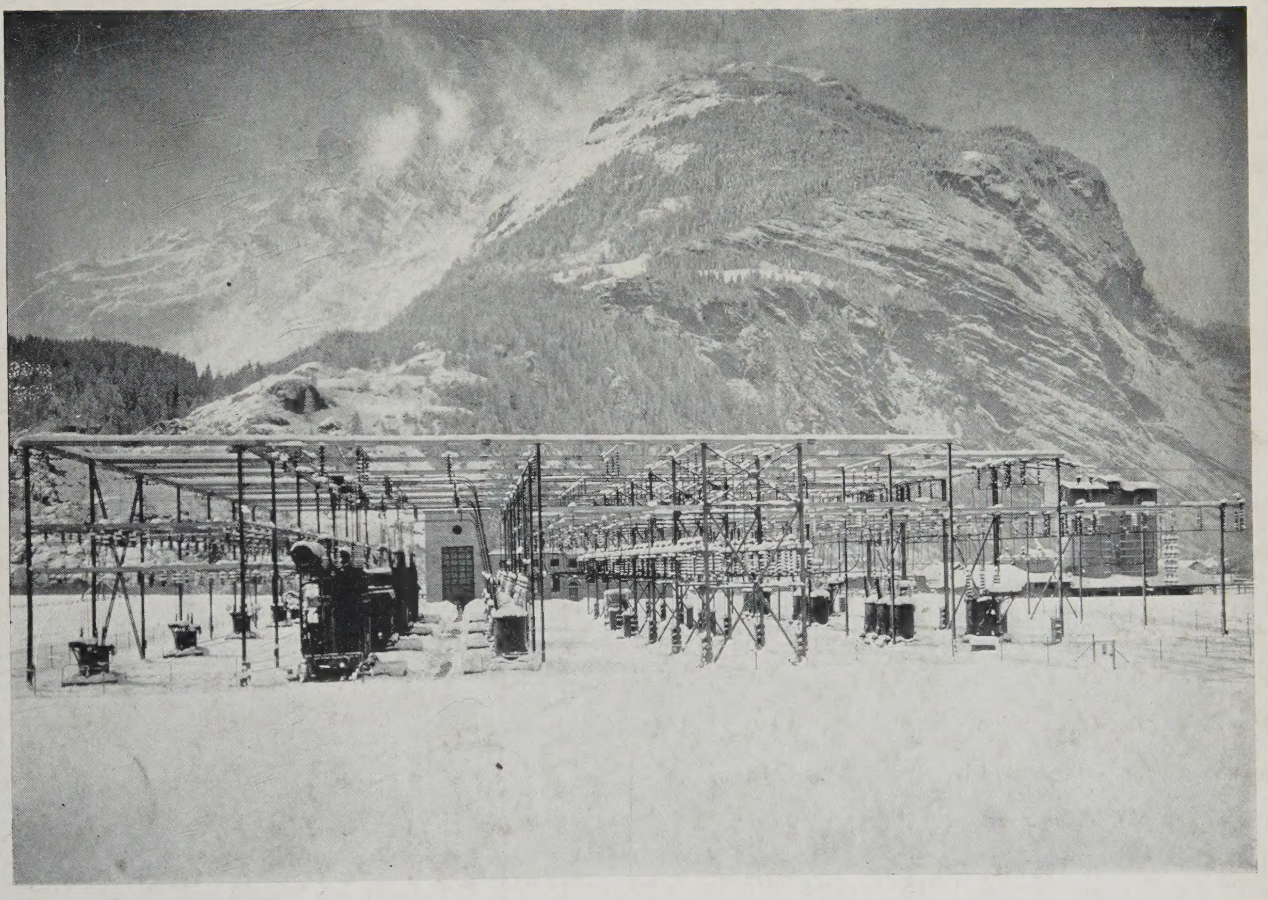

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Future Meetings of the American Institute of Electrical Engineers

Place	Date	Nature	Manuscript Closing Date
Schenectady, N. Y.	May 10-12, 1933	District Meeting	(Closed)
Chicago, Ill.	June 26-30, 1933	Summer Convention	March 26, 1933
Salt Lake City, Utah	Sept. 4-8, 1933	Pacific Coast Convention	June 4, 1933

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
American Institute of Mining Engineers, regional meeting	Chicago, Ill.	June, 26–30	A. B. Parsons, Secy., 29 West 39th St., New York, N. Y.
American Oil Burner Association	Chicago, Ill.	June 12–16	H. F. Tapp, Secy., 342 Madison Ave., New York, N. Y.
American Physical Society	Washington, D. C.	Apr. 27–29	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Physical Society, Pacific Coast meeting	Salt Lake City, Utah	June 16–19	L. B. Loeb, Pacific Coast Secy., Univ. of Calif., Berkeley, Calif.
American Physical Society	Chicago, Ill.	June 19–24	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Railway Engg Association	Chicago, Ill.	March 13–15	
American Society for Testing Materials	Chicago, Ill.	June 26–30	Am. Soc. for Testing Mtls., Phila., Pa.
American Society of Civil Engineers	Miami, Fla.	March 27–31	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y.
American Society of Civil Engineers	Chicago, Ill.	June 27–30	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y.
American Society of Mechanical Engineers	Chicago, Ill.	June 26–30	C. W. Rice, Secy., 29 West 39th St., New York, N. Y.
Maryland Utilities Association	Baltimore, Md.	April 21	D. E. Kinnear, 803 Court Square Bldg., Baltimore, Md.
Missouri Association of Public Utilities	Excelsior Springs, Mo.	April 27–29	N. R. Beagle, 101 West High St., Jefferson City, Mo.
National Fire Protection Association	Milwaukee, Wis.	May 29–June 1	Nat. Fire Prot. Assn., 60 Battery March St., Boston, Mass.
National Fire Protection Association, Elec. Committee Mtg.	New York, N. Y.	March 14–17	A. R. Small, Chmn., 109 Leonard St., New York, N. Y.
Society for the Promotion of Engg Education	Chicago, Ill.	June 27–30	F. L. Bishop, Secy., Univ. of Pittsburgh, Pa.

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This Month—

Front Cover

Innertkirchen transformer station in the Bernese Oberland, Switzerland, where power from the Handeck generating station is received at 50 kv and stepped up to 150 kv for transmission to the load centers in central Switzerland. This station forms part of the Oberhasli hydroelectric development, a short article covering the principal features of which is being prepared for some future issue of ELECTRICAL ENGINEERING.

SCIENCE supplements natural resources by providing not mere substitutes, but products actually equivalent and sometimes superior to those customarily provided by nature. *p. 188–9*

ELECTRIFICATION of the Reading Company's suburban lines in the vicinity of Philadelphia, Pa., has changed a continued loss in traffic on those lines into an appreciable increase. In spite of this increased traffic and faster schedules, however, operating costs are said to be substantially lower than for equivalent service provided by steam. *p. 155–61*

VERTICALLY cut disk sound records possess important advantages over laterally cut records. Marked improvements have been made in the recording and reproducing equipment for this type of record as well as in the processing of the records themselves. *p. 183–8*

PREPARATORY to the transmission of electric power from Boulder Canyon to Los Angeles, Calif., corona loss measurements have been made at line voltages as high as 600 kv, and on conductors as large as 2 in. in diameter. *p. 178–83*

ELECTROCHEMICAL industries are becoming consumers of increasingly larger amounts of electric power, as research laboratories add to the list of products of the electric furnace and electrolytic cell. It is predicted that in another 10 years these industries will require at least 30 billion kilowatthours per year. *p. 151–4*

A NEW electronic recorder, developed for obtaining accurate record charts from the action of a simple indicating electrical measuring instrument, is said to be especially applicable for recording extremely feeble voltages and currents. *p. 168–70*

CONVERSION of electrical energy into light by present day means is extremely inefficient when compared with the theoretical ideal, "cold" light. *p. 173–5*

ANNUAL reports recently were issued and annual elections of officers held by both the United Engineering Trustees, Inc., and The Engineering Foundation. *p. 208–9*

MANY of the Institute's general and technical committees met during the recent winter convention. Brief reports of these meetings are published in this issue. *p. 197–9*

IMPORTANT points brought out in the discussion of papers at the recent A.I.E.E. winter convention are covered in a summarized review of those discussions, the first portion of which is published in this issue. *p. 200–02*

THE condenser-discharge method of controlling 3-electrode gas-filled electronic tubes has proved highly satisfactory in commercial application. In one of these the feeble currents of the photoelectric tube may be used directly to control the gas filled tube. *p. 190–4*

FOUR years' experience in the operation of unattended automatic mercury arc rectifier substations shows that operating and maintenance costs of the rectifier are higher than those of the rotary converter, and that service availability of converters in such stations is greater than that of rectifiers. *p. 194–6*

OVERALL protection of electric power transmission lines by methods utilizing communication facilities between the ends of the line, has been applied successfully to several lines in various parts of the United States. Several types of communication systems are readily adaptable for this purpose. *p. 162–8*

THE contribution of the engineer to the evolution of society may be said to be "something which paves the way for a social condition or situation opening larger opportunities for the kind of a life we really wish to live." So said Dr. John C. Merriam, president, Carnegie Institution of Washington, D. C., in an address at the recent A.I.E.E. winter convention. *p. 171–3*

Economic Conditions and the Engineer

By CROSBY FIELD FELLOW A.I.E.E., Vice-President, Brillo Mfg. Co., Brooklyn, N. Y.

Some phases of present day economic conditions of particular interest to engineers are outlined in this article. An attempt is made to show that conditions are not greatly different from what they always have been, and that there is no need either for any radical change in the established theory of individual initiative or for "any adaptation of more and more socialism under one of the many new-fangled names connected therewith."

IN THE brief space of this article the subject can be dealt with in only the most general way. This is not wholly a disadvantage as it precludes the submission of detailed substantiating statistics. The world is staggering under the volume of statistics at present being poured forth in sufficient quantity and with enough interpretations to be able to prove both sides of almost every question. Nor has the application of higher mathematics to these economic data at present alleviated the confusion, because there are normally several solutions to every equation thus produced, and the selection of the particular solution applying frequently has resulted in still more confusion.

When available data have been studied, however, they all seem to substantiate the fact that our economic progress has been a series of depressions and eras of prosperity following each other alternately. One of the principal factors in the era of prosperity has been expansion, particularly that expansion resulting in construction. New construction has resulted in the putting of funds and credits into capital goods; to make the theorem more vivid, although crude, we might say that while we are building we are putting into circulation in one year funds that we expect will take a period of 10 or more years to amortize the debt thus created. For example, suppose a plant costing say a million dollars is to be built; that plant is expected to be useful for at least 10 years, so it is depreciated off on a 10-yr basis which takes care of the other large amortizable factor of obsolescence. It is a fact, however, that this million dollars which is spent in one year for the building of the plant goes almost completely into wages for labor, and labor normally spends practically the entire amount it receives for consumers' goods of one kind or another. When the building is finished, however, in so far as that particular plant is concerned, construction laborers have no income from that source for 10 years, and unless they find other construction work to do, they are eliminated from the rank of purchasers of goods, both consumable and minor capital, such as home building, automobiles, etc.

One of the most difficult factors in the matter of new construction is the fact that normally most of the money going into this building has been borrowed; therefore the certificates of indebtedness that are issued to cover this borrowing call for their repayment over a period that is at least the 10-yr amortizable period. Consequently, in so far as this particular enterprise is concerned, the credit available for 10 years' building has become exhausted by the expenditure in one year of the money for new construction. Thus the credit for further new construction and the expenditures by the new purchasers created by the receiving of these credits in the form of money for labor might be said to disappear.

"The Automobile Era"

Inasmuch, therefore, as new construction is so vital a factor in the creation of an era of prosperity, it behooves us to find out why the new construction. Large periods of new construction accompanying all eras of prosperity apparently have been occasioned by a noticeable change in the manner of living of a substantial portion of our population. This noticeable change may be of the nature of a migration wherein new cities are built, or new territories opened; or they may be of the nature of a discovery using new materials in old places to satisfy old wants, or newly created wants. Thus we have had eras of prosperity in our history, always followed by their resulting depressions, that have been named: the canal era; the opening up of the Ohio Valley; Westward Ho; the gold rush; the settlement of the prairies; the railroad era, etc. On this basis, perhaps our last era of prosperity should be called "the automobile era."

Not only did the automobile create huge investments in capital goods for factories for the construction of the automobiles, but it built up a vast number of auxiliary industries, some of which, for example, petroleum refining, is in turn a major industry. In addition to that, because of the automobile so many people changed their methods of living that bridges, roads, villages, and even cities had to be built. Further, all this was accomplished in substantially 10 years, and remember that the automobile industry is today the third largest industry in the country.

What perhaps has clouded the issue is the fact that many industries generally considered as manufacturing in reality take the basic part of their demand from construction, for example, the boiler manufacturing industry, the machine tool industry, the

Full text of an address delivered informally at a session of the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933; sponsored by the A.I.E.E. committee on general power applications. *Not published in pamphlet form.*

manufacture of large electric motors and similar accessories, and others. In gathering statistics, therefore, the difficulty is to allocate each of these industries in its proper sphere.

Once the greater number of those people who have changed their manner of living are accommodated in the new manner of living, then naturally we would expect a falling off of new construction, which means the laying off of laborers and the taking out of existence of a proportion of our consumer demand. This, however, is accentuated greatly by 2 factors: (1) methods used in expansion to produce an overexpansion; (2) the fact that this same change in the manner of living which created the need for the new construction has reduced simultaneously the need for the use of certain capital goods adapted to the former manner of living. In other words, capital has been destroyed, and it is vital in these changes that capital should be destroyed, because the never ending increase of certificates of indebtedness if held wholly on a compound interest saving bank method of continued valuation, naturally soon would result in a sum so colossal that none of us can conceive of paying forever interest on both the old and the new construction.

Industry Tends to Overcapitalize

All that this infers is that our viewpoint of the time for repayment of certificates of indebtedness may have to be modified because of our rapid progress, and the issuance of such certificates by such organizations as railroads assuming a life of 20, 40, or 99 years, is wholly out of step with actual conditions. Further, the well-known tactics of those who obtain the money for meritorious new construction (and also perhaps for that which is not so meritorious) is to overcapitalize, if not the particular company in question, the industry as a whole; this surplus of capitalization is, of course, the first to be squeezed out in the ensuing depression.

A factor not generally recognized in its full proportions is that the continuance for a long period of any particular plane of living always results in a long continued depression. This fact seems to be true regardless of whether it is studied in the machine age or in such places as China where the machine age has not yet been introduced and where the period of stability without change from a set manner of living can be studied for centuries. This seems to be due to the fact that once we have become established on the new plane of living, human ingenuity, with or without the devising of machinery, always finds a way of performing the productive functions with less effort and greater skill, resulting in that great "bogey-man" of overproduction. Overproduction was as much a fact in the days of the handicraft laborer, as it ever has been in the days of the machine laborer. Still speaking quite generally, our automobile plant is built and as many of the roads and their auxiliary equipment required for the automobile as our ability to borrow credit will permit.

Of new inventions and new enterprises we have many, but no one of them apparently has in itself the ability to produce that great change in the manner of living of a sufficient number of people to result in that era of new construction so devoutly wished for. Although there is no one invention in the offing as yet announced standing in this position of Santa Claus, yet it is inconceivable that we as a nation are going to put up with so many of the inconveniences that are a part of our daily life; in the elimination of these inconveniences may lie our next big move.

One huge group of inconveniences has been caused by our century-old trend toward concentration of industry in a few centers, and in a few hands. As has been pointed out frequently, this has been due very largely to the use of steam as a source of power, but electrical engineers can begin to take great pride in the fact that electricity, as well as the small internal combustion engine, affords the possibility for the great decentralization movement that is now under way. Probably this will result not in a life on the farm, as the farm used to be called, but in the building up again of the village life in which families may cluster for convenience and yet be near enough to the lands to be easily worked by traveling from the village each day. At any rate, the great growth in our cities as a whole apparently is not continuing, and in the change of the manner of living from city to village life we have the beginning of the era of new construction in which the electrical engineer is fortunately placed.

In preparing to take advantage of these opportunities, however, one caution should be pointed out, namely, that new construction starting because of a changed manner of living most frequently occurs first in small enterprises and with small companies. Therefore, in your industry, do not overlook the advantages of the smaller organizations, and their ability to move quickly to take advantage of local conditions in the manner of living of the population or section of industry that each serves.

New Enterprises Born as Depressions End

In studying depression ends, one remarkable characteristic seems to be the birth of new enterprises. This is obviously natural, but it is not so obvious that the encouragement of these small organizations is a desirable and necessitous prelude to the birth of a new era of prosperity. These smaller enterprises are profitable contacts for the smaller companies in the machinery industries, because of their ability to supply more quickly the new enterprise with equipment more specially adapted to their new needs.

All attempts to legislate or otherwise enforce the continuance of a *status quo* in our manner of living, as for example, certificates of necessity prior to a new enterprise or refusal of credit by banks in order to safeguard present capital, will result only in diminution of progress and its resulting new construction. Without technological advance, resulting in new construction, our profession of electrical engineering becomes superfluous.

To go into these generalities in greater detail would be beyond the intended scope of this article; but an attempt has been made to mention a few of

the major factors affecting us, and to point out that conditions are not so greatly different from what they always have been, and that we do not need any radical change in our theory of individual initiative, or the adaptation of more and more socialism under one of the many new-fangled names connected therewith. It has been pointed out that the desire of a large percentage of our population for a change in its manner of living has created some form of new construction, which in turn has placed in circulation credits in the form of money that the receivers use to spend for goods mostly consumable. When our credit temporarily has been used up, progress temporarily has halted, and we have been in a period of depression.

This type of step-by-step progress necessitates the destruction or non-use of a great deal of capital goods already constructed, and in this destruction and consequent readjustment, credit difficulties occur to many solidly entrenched enterprises. The effect of automatic machinery always has been emphasized in every period of depression, but those countries without technological advances, also have their depressions, and the length of depression seems to be largely a matter of the length of time between 2 progressive steps. Of the great trends, that which is most discernible today is the movement away from congested quarters of city living, and away from centralization of industry in a few financial hands; this trend may be utilized to advantage, particularly by electrical engineers, in the next era of prosperity which surely will be forthcoming to us as a nation as soon as we have taken care of the payment of our debts, or made arrangements for their satisfactory destruction.

The natural tendency during a depression is to blame those very forces that make for progress, and to endeavor by legislation or credit control to protect invested capital and thus maintain the *status quo*. This always results in prolonging the evils of depression.

Small enterprises are a prerequisite to industrial change, and their existence in both consumer and machinery producing groups should be encouraged. Finally, without change in manner of living there are no great technological problems to solve, and without these, there is no reason for the existence of electrical engineers.

Electricity in Chemical Processes

By COLIN G. FINK

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The applications of electricity to chemical processes are increasing at a startling rate. In this article the development of electrochemical processes including the production of many metals and other products is reviewed, and the amounts of electric energy consumed by the various processes over the past 10 or 15 years are given. Predictions are made for a greatly expanding use of electricity in the next decade.

FIFTY years ago when the first electric power plant was completed, and for a dozen years thereafter, practically all of the power generated was used for lighting. Today the lighting load comprises only 10 per cent of the total electric energy produced. Of the balance an ever-increasing proportion is utilized in the manufacture of electrochemical products—metals, carbides, abrasives, solvents, etc. The cradle of the electrochemical industry is Niagara Falls which continues to be one of the largest centers of the world. However, many new electrochemical centers have been established since those momentous days of the eighties and nineties. There are the important developments of Shawinigan and of the Saguenay in Canada; the new center on the Gave d'Aspe in the Pyrenees; the relatively low-cost power plants of Norway and Sweden; the recently completed Dnieprostroy Dam in Russia; the coming center at the Hoover Dam and the portentous developments at Victoria Nyanza in Africa—the continent of the greatest electrochemical potentialities.

Fifty years ago there was no electrochemical industry, and today the industry has spread all over the world with a wide diversity of products approximating an annual value of a billion dollars. Within the last 10 years there has been an increase in output of electrochemical products of almost 200 per cent—10 million tons today as against 3.5 million tons 10 years ago.

Fused Electrolytes

Taking the figures for the last normal year, 1929, we find that the electrical energy consumed by the

Full text of an address "Increasing Applications of Electricity to Chemical Processes" presented before the session on electrochemistry and electrometallurgy at the A.I.E.E. winter convention, Jan. 23–27, 1933, New York, N. Y. *Not published in pamphlet form.*

world's 300,000 tons of aluminum amounted to nearly (7 billion) kwhr—enough electric energy to operate 90 million 75-watt tungsten lamps 3 hours a night for a whole year.

The ultimate production capacity of the new aluminum plant at Arvida, Quebec, is equivalent to the world's output today.

The keynote of the coming new era will be the large number of new products and devices. Among the metals the one metal to enter the widest variety of new fields will be aluminum—aluminum for railway equipment, aluminum for roofs and buildings, for food containers, for transmission, for aeroplanes, for tank cars, pipe lines, fencing, etc. Finally, we should mention briefly the new aluminum plate, superior to tin plate in many respects, developed at the electrochemical laboratories at Columbia University. There is every indication that by 1942 the world's output of aluminum will total 600,000 tons—equivalent in volume to the world's production of copper in 1929. The electric energy requirements to operate the aluminum cells to turn out these 600,000 tons will amount to over 14 billion kwhr—and to this figure should be added the electric energy consumed in the operation of the rolling mills for the production of sheet and rod, and power for the furnaces for the manufacture of aluminum alloys.

Table I—Relative Abundance of the Common Metals in the Earth's Crust

Metal	Parts by Weight*	Metal	Parts by Weight*	Metal	Parts by Weight*
Aluminum	80,000	Chromium	400	Tin	5
Iron	50,000	Nickel	200	Zinc	1
Titanium	4,000	Copper	20	Lead	1
Manganese	800	Cobalt	10		

* Based upon calculations of Washington and others.

Whereas the supply of raw material for many of our metals is comparatively limited in years, the supply of bauxite or aluminum ore is almost limitless. Thus, for example, whereas copper at the 1929 rate of consumption will last but 40 or 45 years, the aluminum ore reserves will satisfy our demands for many hundred years.

From Table I it will be seen that for every pound of copper in the earth's crust there are 4,000 pounds of aluminum. Furthermore, if we take into account that a cubic foot of copper weighs $3^1/_3$ times as much as a cubic foot of aluminum, the comparison in favor of aluminum becomes even more favorable. As raw material today the rich bauxite (hydrated aluminum oxide) deposits of France and British Guiana are preferred; but there are vast deposits of lower grades in the United States, in India, and elsewhere which will be utilized in time, as our processes of extraction and purification improve. Then there are the extensive, almost limitless, deposits of clay—aluminum silicates—which are today being investigated by German and Austrian chemists as possible cheap, raw material for aluminum manufacture. Our civilization has passed through various metal ages—from the ancient iron and bronze ages down to the present chrome-alloy age. The next age will be the aluminum age.

Magnesium Also Important

Aluminum is produced by the fused electrolyte process—the same basic process that is responsible for a host of other metals; most important among these is magnesium. Magnesium is 30 per cent lighter than aluminum. The electric power consumption in the manufacture of magnesium is approximately the same as for aluminum, pound for pound.

The Dow Chemical Company, the largest producer of magnesium metal in this country, reports that "magnesium alloys are now fulfilling the many predictions made regarding them. The transportation industries continue to be their largest users. Aircraft applications are increasing, both in number and volume, and now include parts made from sheet and structural sections, as well as motor, wheel, and miscellaneous castings. Sheet for structural sections is finding still wider use in bus, truck, and trailer construction. Several large manufacturers of portable tools and equipment are finding satisfaction in the use of magnesium alloys. Particularly interesting is their application in foundry flask, pattern, and core box construction where lightness, ease of finish, and ease of parting from sand are important. Bread peels constitute an application in the baking industry. They are both lighter and much longer-lived than the older wooden peels. These expanding applications are the direct result of numerous factors. The cost of both metal and fabricated parts has been greatly reduced. Castings, structural shapes, and sheet are becoming more available. Improvements in rolling technique are being reflected in better physical properties and forming characteristics of sheet metal. The development of chrome-phosphate and chrome-pickle treatments as paint bases has greatly improved the protective action of paints, varnishes, and lacquers. Heat-treated castings are now available with greatly improved yield strengths. Performance in service is substantiating laboratory experiments to prove the stability and utility of magnesium alloys."

It is only a comparatively few years ago when aluminum, magnesium, and sodium were the only 3 metals produced on a large scale by the fused electrolyte method. Today there is a very important list comprising lithium, beryllium, barium, calcium, caesium, and others. The greatest impetus to the fused electrolyte industry has been the progress in aeronautics. Most of the newcomers in the light-metal group are today used as small additions to aluminum and magnesium.

Beryllium

It was one of the world's largest electrical manufacturers, the Siemens and Halske Co., that appreciated the commercial possibilities of the very light metal beryllium for aircraft construction. This com-

pany has carried out a very well planned program of research, and has already achieved some remarkable results. In this country H. S. Cooper of Cleveland, Ohio, has developed an efficient fused salt bath process and there is every indication that the present high manufacturing costs will be very materially reduced in the near future. Beryllium is 4 times as elastic as aluminum and 25 per cent more elastic than steel. Pure beryllium is ductile. It is 17 times more transparent to X-rays than aluminum. The addition of 4 per cent of beryllium to copper increases its hardness 7-fold.

Beryllium occurs widely distributed in nature in a number of well-known minerals. The General Electric Company's mines at Keoflach, Austria, can take care of the world's demands for many years to come.

Lithium, Lightest of All Metals

Another newcomer in the fused salt product group is lithium, the lightest of all metals, less than $^1/_5$ the weight of aluminum. The Allied Process Corporation of New York, N. Y., is now manufacturing this metal on a commercial scale. A few tenths of 1 per cent of lithium added to aluminum ("skleron") develop properties in this metal similar to those of steel. Those intimately connected with the development of the lithium metal and alloy industry are fully confident of a rapidly increasing growth of the industry. Its present price is $15 per pound, which is not high when we compare it with the early prices for aluminum.

Other commercial fused electrolyte products which should command the attention of electrical engineers are metallic sodium, of which many thousand tons have been produced and which has lately attracted world-wide attention through the sodium vapor lamp; metallic caesium for photoelectric tubes; metallic barium, a soft, silvery metal of great promise in vacuum tube application; and metallic calcium for rectifiers of the tungar type. Furthermore, 2 per cent of calcium plus barium added to lead makes the well-known Frary bearing metal.

Among the rare metals the Westinghouse laboratory at Bloomfield, N. J., has developed commercial fused electrolyte methods for the production of thorium, as soft as lead; zirconium; and uranium. All 3 of these metals are of particular interest to electrical engineers. Using calcium metal as a reducing agent, the Westinghouse laboratory has also prepared vanadium metal and drawn it into wire. Important electrical uses for this interesting metal will undoubtedly be found, now that it is available in this practical form. Its melting point is 1,700 deg C and it is one of the least volatile of metals.

Aside from the many new metal (or cathode) products of the fused electrolyte industry, there is a commercially important new anode product, fluorine, which is used as a reagent in the production of various organic chemicals.

The electrolytic copper industry is one of the oldest of the electrochemical group. The increase in electrolytic copper plants during the last half-dozen years has been most phenomenal: 2 new plants in Canada; a large plant at El Paso, Texas; another at Queenstown, Tasmania; at Potrerillos in the Andes; at Panda in the Belgian Congo; at Hoboken, Belgium; and at Moscow, Russia. Between the years 1919 and 1929 the world's copper production just doubled. Electrolytic copper refining does not consume a great deal of electrical energy. However, during the last 10 years a very large proportion of the electrolytic copper produced has been from leach liquors. The voltage of the electro-winning cells is 10-fold that of the electrolytic refining cells. Accordingly, during the last dozen years there has been a marked increase in the consumption of electricity by the copper industry not only due to a doubling of the total output of copper, but due to the introduction of a new electrolytic copper process—the direct recovery from leaching solutions, necessitating a 10-fold rise in voltage.

The case of electrolytic zinc is even more interesting. Commercial production of electrolytic zinc started during the Great War. In 1929 almost 500,000 tons of electrolytic zinc were produced from plants located in every part of the world—the United States, Canada, Italy, Poland, Japan, Rhodesia, Tasmania, France, Germany, and Norway. A half million tons of zinc required $1^1/_2$ billion kwhr —or more than twice the electrical energy consumed for the world's output of copper in 1929.

Electrolytic cadmium is a by-product of electrolytic zinc. In 1919 the United States produced 100,000 pounds of cadmium; in 1929, 2,500,000 pounds. Many electrical fittings are now cadmium-plated, an assurance against corrosion.

We also can record a marked increase in consumption of electricity due to rapid rise in the output of electrolytic nickel, electrolytic platinum, gold, and silver. To this list should be added electrolytic iron. With the marked reduction in voltage of the new cells, the direct production of pipe by electrolytic means is now cheaper than the furnace product. The world's platinum output today, although not all electrolytic, is 300,000 oz—over 6-fold what it was in 1919.

Electroplating

The plating industry of today consumes over 1,000 kwhr for every kwhr consumed 10 years ago. And not only is electrical energy consumed in the deposition of the plate, but appreciable quantities of energy are consumed in the electrolytic cleaning of the articles before plating. A recent interesting large-scale innovation is the complete electric cleaning, plating, and electric annealing of strip steel before stamping and spinning—doing away with most of the former individual racking and handling. In 1919 there was no chromium plating industry and today it has spread all over the world.

Alkali and Chlorine

The electrolytic alkali and chlorine industry is less than 30 years old. Today, over 30 per cent of the world's caustic is made electrically, consuming 1.3 kwhr for every pound produced, or over one billion

kwhr for the world's output in 1929. Chlorine is now shipped in tank cars holding 30 tons of the liquefied gas. Electrolytic chlorine has started an entirely new solvent industry and a new process for the recovery of metals from their ores.

Among the newer aqueous electrolyte processes we should include the production of white lead for paints, better than the product by the old, messy, chemical method. The Anaconda company at East Chicago has turned out many hundred tons of white lead according to the electrolytic process invented by the late Elmer Sperry of gyroscope fame. Another aqueous product is electrolytic rubber. The process is based upon the fact that colloidal rubber particles will migrate to the anode by electro-osmosis or anaphoresis. Millions of rubber articles have been made by this "anode" process.

The Electric Furnace and Its Products

Among the electrochemical industries the calcium carbide industry is undoubtedly one of the largest consumers of electrical energy, with the combined ferro-alloy and electric steel industries a close second. The first calcium carbide plant was built in 1892 at Spray, North Carolina. Within the next half dozen years carbide plants sprang up in every corner of the globe. The carbide was interacted with water to produce acetylene—a serious competitor of the old Edison carbon lamp. With the perfection of the tungsten lamp, acetylene lighting declined, but a new application now spread rapidly—oxyacetylene welding and cutting. Another important byproduct of the carbide industry was introduced in 1904—calcium cyanamide, $CaCN_2$, at one time the cheapest source of fixed air nitrogen. Cyanamide is today the raw material for practically all of the cyanide used in gold mining. From this cyanide, in turn, hydrocyanic acid gas is derived, now employed on a very large scale as an insecticide and vermin destroyer. Our citrus groves could not get along without this calcium carbide byproduct. Another series of byproducts developed on a large scale during the last 10 years includes the chloride derivatives of acetylene among which trichlor-ethylene has become a very important solvent.

Table II—Annual Electric Energy Consumption by a Few of the Electrochemical Industries (World Output)

Product	Tons Produced in		Thousands of Kwhr Consumed in	
	1919	1929	1919	1929
Aluminum	150,000	300,000	3,700,000	7,000,000
Copper (electrolytic)	900,000	1,800,000	250,000	600,000
Zinc (electrolytic)	70,000	500,000	240,000	1,500,000
Caustic and chlorine	150,000	400,000	400,000	1,040,000
Calcium carbide	900,000	1,600,000	2,520,000	4,160,000
Electric steel	800,000	2,200,000	480,000	1,100,000
Ferro-alloys	220,000	550,000	1,320,000	3,000,000
Abrasives*	50,000	150,000	280,000	750,000
Total of products listed	3,240,000	7,500,000	9,190,000	19,150,000
Estimated grand total**	3,500,000	10,000,000	10,000,000	21,000,000

* Silicon carbide and artificial emery (corundum).

** In the "grand total" are included carbon and graphite electrodes, electrolytic nickel, chromium, lead, silver, gold, and cadmium; also magnesium, sodium, tungsten, molybdenum, quartz, phosphorus, carbon bisulfide, cyanides, oxygen, hydrogen, and miscellaneous other products.

The original carbide industry has today grown to a far-reaching chemical industry with a hundred-odd byproducts, to which new ones are being added every year. Much of the vinegar we consume at our table today is a carbide byproduct.

The electric steel industry has likewise had a phenomenal growth. In 1909 there were a dozen or so electric steel furnaces operating in various parts of the world. Today there are over 1,200. And many of the new alloy steels—such, for example, as the high chrome steels—cannot be made in any other than the electric way. With the electric furnace and its controlled atmosphere, its high temperature and rapid operation, we can produce alloys of new and wide commercial application: alloys of high tensile strength or of extreme hardness, or of special magnetic properties, or of decided corrosion-resistant characteristics.

Paralleling the rapid growth of the electric steel industry is the growth of the ferro-alloy industry. The metals are ferrochromium, ferromanganese, ferrosilicon, ferrosilico-zirconium, ferrovanadium, ferromolybdenum, and others. All of these alloys are used primarily in the steel industry, but the modern alloy steel industry could not exist without another important electric furnace industry, the abrasive industry, silicon carbide, and corundum. Many of the new steels must be cut and finished with these electric abrasives. Every pound of carborundum consumes 3.5 kwhr during its manufacture. A new electric corundum plant was recently completed at Niagara Falls, Ontario, and another new one in England.

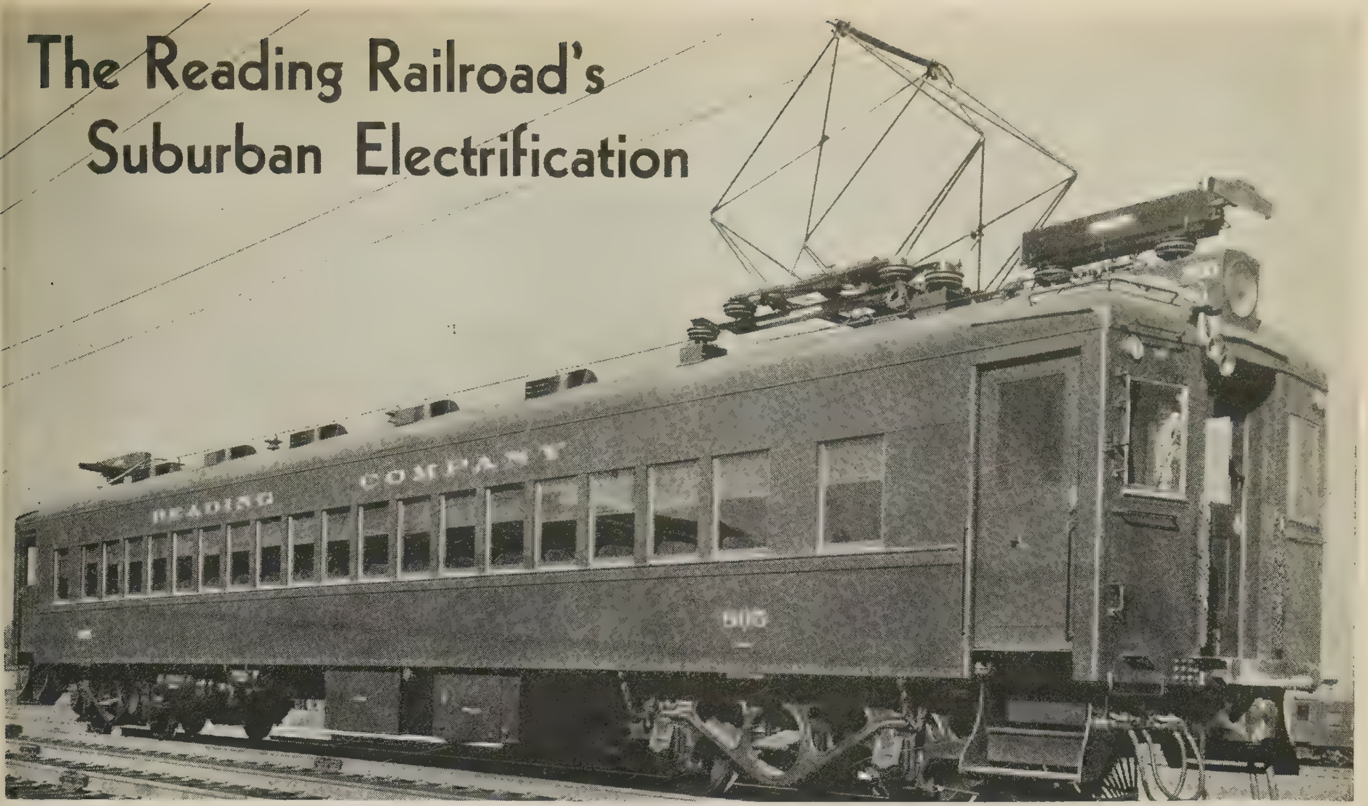
There are many other electric furnace products upon which our present civilization is dependent such as: phosphorus and phosphates, carbon-bisulfide for the rayon industry, carbon and graphite electrodes, graphite lubricants, silicon, tungsten, and clear fused quartz.

Outlook for the Future

Our research laboratories are continually adding to the already portentous list of products of the electric furnace and electrolytic cell. What may we expect in another 10 years? How will these electrochemical products affect basic industries? Indications of radical changes are already evident. Railroads will completely modify design and structure of their equipment, speeds of 100 miles per hr will be common. Our new transatlantic steamers will profit by the experience of the high-speed motor boats and aeroplanes, and the aeroplanes, too, will be much lighter in weight and operate at higher speeds. Our buildings will no longer be encumbered with heavy walls and floors, but glass and metal will predominate.

And as to future electric power consumption for electrochemical industries, we can safely predict that in another 10 years it will be twice that which it was at the peak, in 1929; it will be at least 30 billion kwhr per yr, or about $^1/_3$ the total power generated in the United States today.

The Reading Railroad's Suburban Electrification



In spite of a doubling of trains and train miles, and schedules faster by 20 per cent, the cost of suburban operation has been lowered substantially by electrification. Resulting service improvements have changed an appreciable traffic loss to a traffic increase. Important details of the system and its equipment are described here.

By
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ELECTRIFICATION of the Reading Suburban Service in the vicinity of Philadelphia was authorized October 25, 1928, and was placed in operation July 26, 1931. The lines now under electric operation include 65 route miles and 157 track miles which will be increased by January 1, 1933 to 87 route miles and 203 track miles, as shown in Fig. 1. Steam operation in this territory has been in service for many years, the Reading being one of the oldest railroads in the United States. In the last 10 years, however, it has met severe competition, from private automobiles, buses, a new subway, and the Pennsylvania Railroad's electrified lines, that has resulted in serious loss of traffic and revenue to the railroad.

The Reading Company was faced with two alternatives: either to continue steam operation, where the only means of cutting cost of operation was to reduce the number of trains thus further impairing the service and resulting in additional losses of traffic, or to provide a modern, superior electrified service which in addition to other advantages, would reduce materially the operating cost per train mile. It was believed that electrification would justify the more frequent operation of trains which, with a 20 per cent increase in schedule speeds, greater cleanliness, and more attractive equipment, would attract an increased traffic.

In the general design of the electrification and the choice of system and of transmission voltages, it was necessary to give careful consideration to future electrification plans for the system as a whole. The single-phase 25-cycle system of electrification was adopted as fulfilling these requirements and at the same time had the advantage of being similar to the system used by the Pennsylvania Railroad in the electric operation of its Philadelphia suburban service and its electrification from Washington to New York, now under construction.

Power Supply

Power is purchased from the Philadelphia Electric Company and is delivered at 25 cycles from a frequency changer station at Wayne Junction adjacent to the Reading Company's main substation. A 3-wire distribution system having 12 kv between trolley and rail, 24 kv between feeder and rail, and 36 kv be-

Essentially full text of "The Reading Company's Philadelphia Suburban Electrification" (No. 32-109) presented at the A.I.E.E. Pacific Coast convention, Vancouver, B. C., August 30–September 2, 1932.

Fig. 1. The Reading Railroad's suburban electrification zone

tween feeder and trolley wire was adopted to transmit the power to the railroad's 9 autotransformer substations. (See map.) Provision is made for the addition of duplicate single phase, 66-kv transmission lines to parallel this 3-wire system. Electrification beyond the initial territory can be carried out by using either a 2- or a 3-wire distribution system fed from one or more outlying points through suitable step-down transformers. This arrangement permits tapping the 66-kv lines at any desired intermediate points to augment the 3-wire system through so-called "three-winding" transformers. Each of these substations is designed on a unit basis and so arranged that the present installation of 1, 2, or 3 2,000-kw autotransformers may, as loads increase, be moved to outlying points and replaced with 4,000-kw transformers without change to the substations. All substations and switching centers are unattended and are operated by supervisory control. Details of the power contract, power supply system, substations, and supervisory control, are described in the articles listed in the bibliography, and in the interest of brevity are omitted here.

Catenary Structures

Most of the catenary structures are composed of steel H-section columns and crossbeams rigidly connected by knee braces to form self-supporting portal structures. This type of construction for electrification structures has the following advantages.

1. Low cost of steel per pound.
2. Ease of detailed design and simplicity of shop details. These were made in the railroad's drawing room at a saving in time and expense.
3. Ease, speed, and low cost of fabrication.
4. Simplicity of construction with resulting good appearance.
5. Ease of painting with resulting economical maintenance.
6. The H-section has greater strength in one direction than the other and in this way can be used to take care of all the varying load conditions which arise.

In the 5-mile section between Reading Terminal and Wayne Junction, where there are 4 or more tracks on an elevated structure, the restricted right-of-way necessitated the carrying of transmission circuits on masts instead of on the catenary columns. This required the use of fabricated trusses instead of H-section crossbeams. These masts were located so as to provide adequate clearance between the wires and any present or future buildings on the properties adjoining the right-of-way.

In outlying sections the structures have H-section columns and H-section beams. However, in cases where the crossbeam spans 5 or more tracks, beams composed of 2 channels laced top and bottom and placed with webs vertical and bolted to the flanges of the columns, are used. For single-track lines self-supporting columns with brackets for supporting the

Fig. 2. Supervisory control desk at the power dispatcher's office

catenary are used; on curves these columns are back guyed.

Signal lights are mounted on the catenary structures in sections where there are 3 or more tracks. Instead of providing special structures at such points, to accommodate signals, walkways, signal supports, and platforms were added to the standard catenary structures. The beam type of structure, however, was changed from H-section beams to channel beams in the cases where signals are carried. On trusses the walkways, signal supports, etc., were attached easily by means of J-bolts.

All structures were designed on the basis of standard Class B loading: $^1/_2$-in. ice with 8 lb per sq ft wind on wires and 12 lb per sq ft wind on flat surfaces. Also alternate loadings of 20 lb per sq ft on bare wire and 30 lb per sq ft on flat surfaces.

Broken wire loads of 1,000 lb on column or of 2,000 lb on beams also were used. Under these loadings a maximum fiber stress in steel of 25,000 lb per sq in. was allowed in net section.

Foundation reinforcing steel and concrete is stressed to 20,000 and 800 lb per sq in., respectively. Soil pressures of 4,000 lb per sq ft on cinders and 5,000 lb on earth were allowed.

Transmission Lines and Catenary System

Bearing in mind the possibility of future "through" electrification to New York, Bethlehem, and Read-

ing, main line catenary structures provide for the installation of a double circuit 66-kv transmission line, although at present the only transmission lines carried are the 24-kv feeders or "balance wires" for the 3-wire system. On single-track branches, only one of these feeders is used, and on 2- and 4-track sections 2 feeders are installed. All catenary columns are interconnected by a ground wire which is clamped to the pole cap with a special fitting. These ground wires serve to protect against lightning, to ground the structures, to assist the trolley rail circuit as regards conductivity, to reduce inductive interference, and to prevent excessive deflection of the structures in case of broken transmission or catenary wires. Following the usual practice in railroad electrification, all lines have been heavily insulated. On the 12-kv catenary lines, 3 standard 10-in. suspension units are used in series, and on the 24-kv feeders, 4 units are used, and it is proposed to install 6 units on the 66-kv circuits. All clearances have been made sufficient to accommodate this insulation.

The catenary system from Reading Terminal in Philadelphia to West Trenton on the New York line, is of the conventional compound 3-wire inclined type. The messenger is a $^9/_{16}$-in. bronze cable, the auxiliary is a 2/0 grooved copper wire, and the contact wire is of 4/0 bronze wire. Supports for this type of construction are 300 ft apart on tangent tracks and fitted

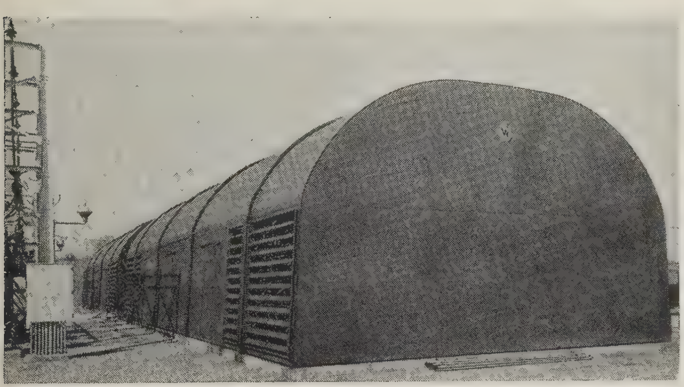

Fig. 3. Outdoor frequency changers help to minimize substation buildings

with windsteadies except where high buildings or embankments protect the catenary from the wind.

On tangent sections of all other electrified tracks simple 2-wire inclined catenary is used comprising a 0.636-in. composite bronze and copper messenger and a 4/0 grooved bronze contact wire suspended from the messenger by lifting loop hangers; structure spacing is 250 ft and no steadies are used on the contact wire. This is the first installation in the United States of long-span steel-structure simple catenary, and its use has resulted in simplicity and ease of erection and maintenance, and superior quality of current collection. The simplicity and other advantages of the air gaps used with this type of catenary also are gratifying.

All catenary and transmission lines were designed to take a stress well below the elastic limit when loaded with $^1/_2$-in. radial coating of ice at 0 deg F. Variation in alinement of the inclined catenary due to changes in temperature was calculated prior to erection, and where excessive lateral movement appeared to be likely, steadies were placed on the contact wire. Greatest movement was found to occur on the compound catenary on curves where the hanger slope is about 45 deg.

All hangers, clips, steadies, and similar objects are bronze of a composition highly resistant to corrosion. In compound catenary on tangent track, the hangers are clipped to both main and auxiliary messengers, the hangers alternating with clips which fasten the contact wire to the auxiliary. On the simple catenary on tangent track, loop hangers are used, a protecting sleeve being placed over the messenger at each point to eliminate wear. In every second span of simple catenary on tangent track a feeder jumper of flexible cable joins the contact wire to the messenger; the loop hangers, therefore, are required to carry only a negligible current. Inclined hangers on curves, identical on both the simple and compound catenary, comprise a $^3/_8$-in. rod, upset to $^7/_{16}$-in. at the lower end and provided with a shoulder to receive the contact wire clips.

The car storage yards and the Reading Terminal are wired with cord catenary, consisting of a $^7/_{16}$-in. messenger and a 4/0 contact wire. In all wired crossovers, and at sectionalizing points in the main line, air breaks are installed. Wood stick insulators are used only where it was not possible to use air breaks.

Where highway bridges pass over the tracks, the catenary is carried on rigid post type insulators erected on brackets on each side of the bridge. A minimum clearance of 6 in. from the messenger to ground is permitted at certain points, but the desired standard clearance is 9 in. or more. The standard contact wire height is 22 ft and in approaching overhead bridges the gradient in the contact wire is kept down to 0.5 per cent relative to the track. Protec-

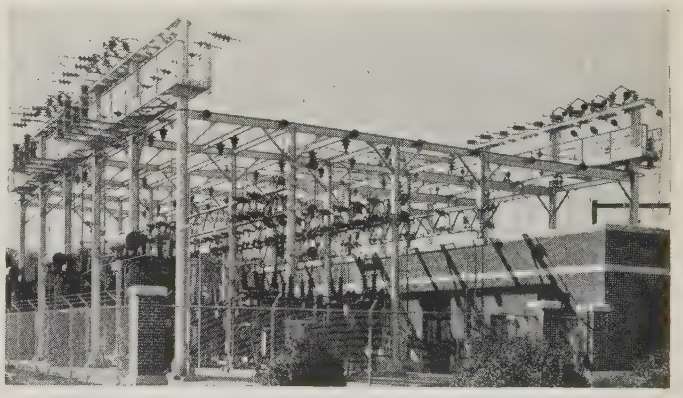

Fig. 4. A typical transformer substation

tive screens were provided to make the contact system inaccessible to persons on the bridges.

Prior to erection of the contact line, all stringing tensions and hanger lengths were so worked out in the office that field adjustments were reduced to a minimum. One of the construction difficulties met with was in connection with the inclined catenary

where the stringing tension curves are less than on tangent sections. To take care of this inequality during the tensioning of the messenger cable, the messenger was snubbed on every curve until the contact wire load was added, after which the messenger assumed its proper tension and the snubs were removed.

Rail Bonds

The standard rail section of the Reading system is a 130-lb head-free type, and the joint is one developed for use with this rail. Because the bead on the joint projects a considerably greater distance than usually is the case, the joint and rail have a cross-section not particularly adapted to the application of bonds. The traction bonds selected for installation on this system are of No. 1 A.W.G. gas welded 8-in. straight type.

On all main line tracks the rails are a part of the 100-cycle a-c track circuit. In order that the rail return may be continuous, impedance bonds having a continuous rating of 100 amp per rail are provided around the insulated joints. These permit the traction power to flow, but offer high impedance to the flow of signal current.

To ground each structure effectively all structures wherever possible are tied together by means of ground wires, the ground wires being bonded to rail through impedance bonds, usually at the end of every other track section so as to provide maximum broken rail protection. Cross bonds of insulated 2/0 cable interconnecting the rails of all bonded tracks are installed at frequent intervals. As in all cases wherever there is any possibility of maintenance of way forces disturbing the installation, a covering of fiber impregnated planking is installed directly over the cable and the whole covered with earth.

Each of the Reading motor cars is a complete unit, equipped with motors, storage battery, air compressor, cab signals, and a control cab at each end. The liberal use of aluminum resulted in a saving of 6,640 lb per car, the estimated annual saving in power cost from which is considerably more than the interest on the added investment. The trucks, sidesheets, underframing, and all stress carrying members are steel.

Trailer cars were converted from steam cars, equipped with electric heaters, cab signals, and a control cab at both ends, to give maximum flexibility of train operation. The present operating schedule calls for the use of trailer cars only in rush hours, the ratio of one trailer car to 3 or more motor cars. Because the trains on which trailers are used are largely on express runs, the schedules and motor heating are not greatly affected by this method of operation.

In the motor cars 37 cross seats placed $33^1/_2$ in. from center to center provide seating capacity for 74, with ample leg room; 3 longitudinal seats each seating 4 passengers. Variations from this capacity are indicated in Table II. A bright, clean appearance is provided on the interior through the use of a 3-tone gray paint finish striped in blue and gold, and hardware, baggage racks, and light fixtures of a sanded nickel finish. Brass window sashes eliminate sticking, and add to the attractive appearance of the cars. Signals are electrically operated by means of pushbuttons, thus eliminating signal and emergency cords through the cars; an emergency cord in the vestibule is accessible from the inside of the car. A conductor's signal button is provided over each vestible end

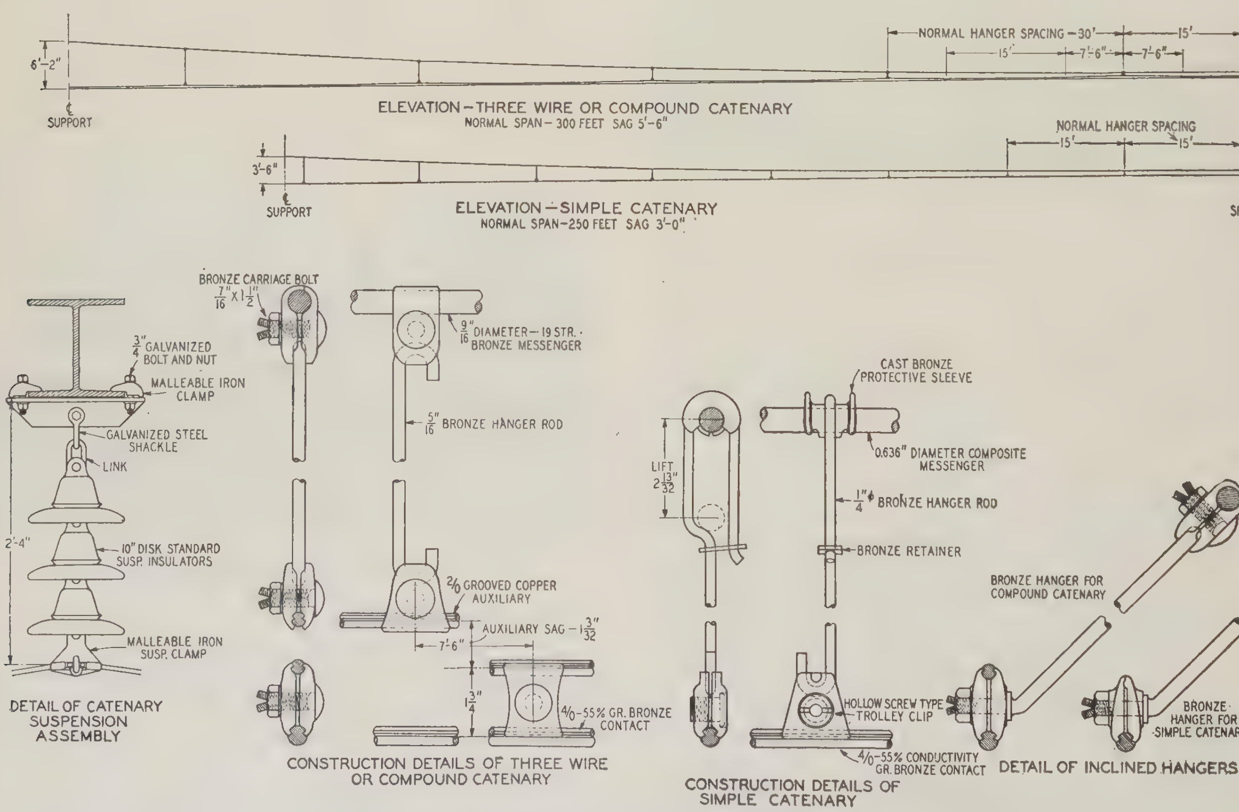

Fig. 5. Typical catenary details—Reading Company's suburban electrification in Philadelphia and vicinity

Table I—Different Wires Used on the Reading Railroad Electrification

Size Wire	Purpose	Material	Equiv. Cross-Sec. in Cir Mils of Cu	Weight Lb per Ft	Ultimate Strength	Normal Tension	Max. Work Tension
9/16-in. diameter	Messenger	Bronze stranded	34,000	0.744	19,750	3,820	7,500
0.636-in. diameter	Messenger	Comp. bronze and copper	211,600	0.935	19,100	4,340	7,675
4/0	Contact	Bronze (grooved)	116,400	0.641	10,200	2,500 3,000	4,170 4,670
2/0	Auxiliary	Copper (grooved)	133,000	0.403	5,220	1,200	2,200
7/16-in. diameter	Messenger (yards)	Bronze stranded	20,900	0.457	12,150	2,490	4,830
2/0	Feeder and ground wire	Copper stranded	133,000	0.411	6,270	830	2,350
4/0	Feeder and transmission	Copper stranded	211,600	0.653	9,970	1,320	3,140
No. 1	Signal circuit	Copper stranded	83,700	0.255	3,740	520	1,820

door; supplementary buttons on the outside under each corner post enable the conductor to save a little time at each stop by not having to board the train before giving the starting signal.

One outstanding development of the Reading cars is the bus connector which enables all pantographs to be connected together, thus providing power on all cars when only 1 or 2 pantographs are in service. It is expected that the use of this device will show considerable savings in trolley and pantograph shoe wear. This already has shown its value in making possible the continuance of a trip with power on *all cars* after pantographs have been damaged on several of the cars in a train.

A magnetic door latch has been developed and installed on the doors between the vestibules and passenger compartments of the cars to insure these doors being open a minimum length of time, thus reducing drafts and conserving heat. This latch holds the doors open during the time a train is coasting to a stop and standing in a station, but automatically releases the doors upon starting, allowing them to be closed gently by an ordinary air cushion door check.

Double thermostat control of the electric heaters is used, one thermostat being set at 50 deg F and the other at 65. These thermostats are so connected that when the motorman has his controller plug in the master controller the 65-deg thermostat is connected, but when he leaves his cab, as during short lay-overs at terminals, the 50-deg thermostat is cut in automatically. This enables the cars to be kept moderately warm during a lay-over. Of course, when the car goes into storage and the pantograph is lowered the heat is all cut off. Switches also are provided for cutting off the heat during warm weather.

The motorman is provided also with a "train heat" switch which enables him to change all thermostats in the train from the 65-deg to the 50-deg setting. Operating rules require him to cut off his train heat 10 min before reaching his terminal, unless the equipment is going to remain in service. This results in a considerable saving in heating power cost.

A new design of ventilating system is used which insures sufficient air being delivered to the motors and transformer at all times. Special attention was given to the cleaning of the air and to keeping the velocity low. A "no blower cut-out" is installed to prevent the operation of a car in case of a failure of the ventilating system.

Eighty cars are equipped with Taylor flexible trucks and 20 with Commonwealth trucks. The Taylor truck has been used before on freight cars and

Table II—Reading Multiple Unit Cars

Type of Car	No. of Cars	Seating Capacity	Baggage Space	RPO Space
Motor	89	86	0	0
Motor	9	62	17 ft 1 in.	0
Motor	2	38	16 ft 8½ in.	17 ft 1 in.
Trailer	20	84	0	0
	120	Total		

on some experimental installations of passenger cars and locomotive tenders, but this is the first time it has been used on electric cars. Its advantages are, greater flexibility and lighter weight.

Motors and Control

Because short runs and severe grades made desirable the use of traction motors as large as possible within space and other design limitations new designs were developed by the manufacturers. These new designs produced a motor with a 1-hr rating of 300 hp and a continuous rating of 240 hp. Improvement over prior designs is brought about by using a larger number of poles, thus permitting a low flux density which in turn produces better commutation. In addition, the weight per horsepower is considerably less than with previous motors, while exceptionally high values of efficiency and power factor have been made possible.

An accelerating rate of 1.25 mphps is obtained in service with a normal voltage of 11 kv at the pantograph and with full seated load, a total car weight of about 70 tons. This weight is divided, 60 per cent on the motor truck and 40 per cent on the trailer truck, resulting in a low adhesion of 10.4 per cent and consequently very little wheel slipping.

The accelerating rate is the highest yet attained on a-c equipment, and even though it is less than generally used on d-c multiple unit equipment it results in a higher scheduled speed in a service in which the average length of run is more than 0.8 mile. For example, although it takes 24 sec for a car to reach 30 mph it takes only 60 sec to reach 50 mph. Another example of the sustained horsepower of these motors is the fact that a 2-car train has a balancing speed of 56 mph on a grade of 1.13 per cent. On level tangent track the balancing speed is between 75 and 80 mph, depending upon the length of train. However, the equipment is restricted to a maximum speed of 72 mph.

The automatically accelerating main controller is located under the car and controlled remotely through a 32-volt circuit from a master controller in the cab. The master controller has the "dead-man's" release, further equipped with a foot pedal to hold it in position so that the motorman can have both hands free if desired.

Although the motor and control equipment was furnished by three different manufacturers, and two different types of trucks were used, it was possible by careful design to build all the cars from one set of drawings and to use one schedule of hangers. The traction motors and air brake rigging are so designed that it is possible to interchange the two makes of trucks.

Fig. 6. (Right) Typical 4-track section with compound catenary

Fig. 7. Typical 2-track section with simple catenary

Careful attention also was given to the arrangement of apparatus on the underside of the car so as to simplify inspection and maintenance. The flexible connection through which the air passes to ventilate the motors is designed so that it automatically disconnects itself when the motor is removed and then automatically goes into place when the motor is replaced.

A spring motornose suspension is used that can be removed readily permitting the motor to be dropped out of the bottom of the truck by a special pit jack in the shop without removing the trucks from the car. The motor also can be lifted out of the top of the truck in the ordinary manner if desired. A wheel pit has been built into the shop so that wheels can be dropped without removing either the truck or the motors, thus eliminating the necessity of disconnecting the motor leads when changing wheels. These pit jacks also can be used to remove the transformer, compressor, and other apparatus.

The storage yard is at Wayne Junction and is designed to accommodate 86 cars at present and 160 ultimately, keeping one track open as a run-around track.

The new shop is located near the center of the storage yard and is provided with 5 tracks, 3 for light inspection and 2 for heavy repairs. All tracks are long enough to accommodate 4 cars and are arranged so that the cars can be routed progressively into one end of the shop and out of the other. This gives the shop a capacity sufficient to maintain more than 200 cars. Room is provided for an extension of 125 ft on the heavy repair bay for the maintenance of future electric locomotives.

Inductive Coordination

Advance realization of the necessity of coordination of the electrification and local communication facilities, railroad and commercial, resulted in the railroad's plans being discussed from the beginning with representatives of the telephone and telegraph companies. Inductive coordination was kept in mind during the design of the electrification, and cooperative tests were made before the start of electric operation.

From results of more than a year of operation there has been no trouble due to inductive disturbances in either railroad or commercial communication facilities.

Construction Features of the Work

The installation of the work in its entirety, with the exception of buildings for car shop and substations, was done by the railroad's construction forces organized for the purpose and under the supervision of the electrical department. The construction features of such an installation are complex and expensive, and made difficult due to the necessity for maintaining traffic without delays. After surveys were made and plans issued to the field forces, the first step was the installation of foundations for catenary structures. Because of congested right-of-way, particularly between Reading Terminal and Wayne Junction, where the railroad is on an elevated structure, and where in many cases the center of the outside tracks is only 7 ft from the right-of-way line, the installation of foundations was particularly difficult and expensive. It was necessary to go to extensive shoring of the tracks in order to maintain traffic, this

feature alone for this 5 miles of railroad costing $40,000. The concrete for the foundations was all mixed and poured from concrete mixing plants installed on cars and operated in work trains. Water was supplied to the mixer from tank cars insulated against cold and heated in winter with steam from the engine. Approximately 35,000 cu yd of concrete were used in the work.

Steel structures were erected by means of a derrick car, purchased for the purpose, which could be operated on one track without obstructing traffic on adjacent tracks. Steel was shipped from the fabricator in cars so loaded that it could be unloaded in the order in which it was to be installed; thus eliminating rehandling.

Transmission wires were strung by means of teams of horses in the manner customary for power lines. The messenger, auxiliary, and trolley cables were strung from reel cars through temporary sheaves attached to the bottom of the suspension insulator strings.

Because both the service cost of work trains and the degree of their interference with normal traffic are high, every effort was put forth to keep their use at a minimum. Although all wires, fittings, and related material were installed from tower cars in work trains, all wires and fittings were preassembled, marked for the span or the structure where they were

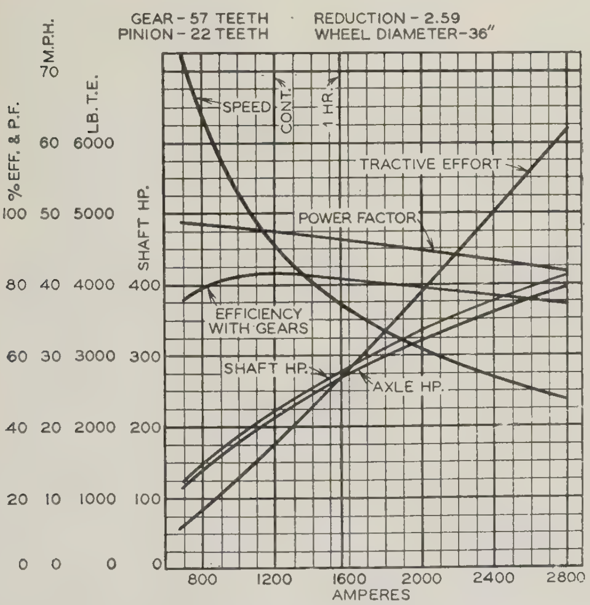

Fig. 8. Characteristic curves of Reading motors

Curves taken with 170 volts, 25 cycles, applied to 170/340-volt, single-phase, 25-cycle railway motors

to be installed, and delivered to the proper location in advance of the work train schedule.

Substation steel and apparatus were installed in the customary manner. Supervisory control equipment was installed by the substation construction forces. Concurrently, bonds were being installed, wire crossings eliminated or altered, signals and communication changes made, additional yards installed, tree trimming and many other details attended to. As soon as power was available and a section was completed, everything was thoroughly tested out with particular reference to obtaining proper selectivity on the circuit breakers. Actual short circuits to ground were placed on every circuit of the network. The system of relaying was new, and some adjustment of relays was found necessary.

Such a construction program required close cooperation from the purchasing, stores, signal, telegraph, engineering, and motive power departments, and particularly the operating department. During a considerable part of the time, there were as many as 20 work trains in use.

Several months before the start of operation, the training of the steam enginemen who were to operate the new equipment, the inspectors and shop forces that were to maintain it, and the power dispatching and maintenance forces, was started. All electric trains on all branches were placed in operation simultaneously on the morning of July 26, 1931.

As in all terminal electrifications, extensive improvements were made concurrently with electrification, and the cost of all these associated improvements exceeded the cost of the electrification construction itself, including rolling stock. In the case of the Reading electrification, the related improvements included: elimination of grade crossings; obtaining required additional clearances to permit the installation of overhead wires for overhead bridges where overhead bridges or other obstructions were met with; building new suburban car storage yards at outlying points, and a new yard for storing cars at Wayne Junction during the middle of the day; change and modernization of the signal system and the placing of communication circuits in cables, underground where right-of-way was restricted; and 9 new substations at various points in the suburban territory.

Results

In spite of schedules faster by 20 per cent and an increase in trains and train miles of approximately 100 per cent, the cost of operation is substantially lower than for the service in the same territory by steam. A continual loss in traffic has been changed into an appreciable increase and as a result of this showing, the railroad management has authorized the electrification of suburban service from Philadelphia to Norristown. This service, along with the Chestnut Hill Branch, will go into operation about January 1, 1933.

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Relay Systems Utilizing Communication Facilities

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Overall protection of transmission lines may be secured by the use of a communication system to (1) compare the relative direction of fault current flow at line ends, or (2) link the tripping circuit at the line ends. The various types of communication systems adaptable for relay purposes are considerd in this article.

OVERALL protection of a section of transmission line, insuring tripping of both ends of the line section instantaneously for all faults on the section, and non-operative for system faults not on the section, represents very nearly the ideal relay system. The protection afforded by other more common relay schemes, such as selective timing or balanced relay schemes, even when reduced to a high speed basis, falls short of the ideal in several important respects.

Three forms of overall protection which have been applied may be identified by the following terms: differential protection, directional comparison, and transferred tripping. The first of these, differential protection, requires a-c pilot wires connecting the secondaries of current transformers at opposite ends of the line; the disadvantages of a-c pilot wires have prevented the widespread use of this method. The other 2 forms of overall protection, utilizing communication facilities between the ends of the line, are considered in this article.

During the past few years overall protection has been successfully accomplished on a number of transmission lines throughout the country by the application of methods whereby the relative instantaneous directions of residual current, or the relative directions of fault current flow at each end of the line, are compared by a communication system which is arranged to trip both ends of the line when the relation obtained indicates that the line is faulted. These methods, while differing as to the details of the relay or the communication systems used may be given the title directional comparison. Overall protection by directional comparison using a communication system as the auxiliary link between the line terminals has advantages over differential protection because a reliable communication system can be provided more readily and at less expense than a-c pilot wires.

Communication facilities also may be employed as an adjunct to a selective timing relay system of any type to permit the simultaneous tripping of the breakers at both ends of the line upon the operation of the relay system at either end. This system, which may be termed transferred tripping, is useful in cases where selective timing relay systems may be employed to give instantaneous operation at one end of the line under all fault conditions; and where, due to stability considerations it is necessary to trip both line ends instantly without waiting for sequential or second zone operation at either end.

The communication facilities required for either of these protective schemes are those of a telegraph system. The medium employed may be the transmission line itself by means of carrier-current, or else telegraph or telephone circuits either owned by the power company or leased from a telephone company. The choice of the particular communication system to be used will depend upon a wide variety of local conditions and considerations.

Overall Protection by Directional Comparison

The underlying principle of operation of the directional comparison method of relay protection is based upon the fact that the presence or absence of a fault on a transmission line can be determined from a knowledge of the relative directions of power flow at each end of the line. As an example, consider the usual case of a transmission line running between 2 stations, each of which is connected to a generating source, and assume that this transmission line is provided at each end with a power directional relay arranged to close its contacts when power flows into the line at that end. With this arrangement it will be seen that under conditions of normal power transfer over the line in either direction, the contacts of the directional relay at the receiver end of the line will always be open. This same condition holds in the case of a through fault in either direction.

If a fault occurs on the line, however, power flow at each end of the line will be toward the fault and both directional relays will close. In Fig. 1 is shown the communication circuit which automatically compares the relative directions of power flow at the ends of the line and initiates the tripping operations under proper conditions. This relay protective system performs in exactly the same way as the conventional system of differential protection.

It is possible to design this equipment so that all conditions of fault can be met, even when either end of the line protected may not always be connected to a generating source. In the case of tapped lines, it may be necessary to install a directional relay system at the end of the tap and to connect the communication system to this point as well.

Essentially full text of "The Use of Communication Facilities in Transmission Line Relaying" (No. 33-3) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.

In practice, the single directional relay shown in Fig. 1 is usually a directional relay system consisting of a group of relays designed to operate properly under all possible fault conditions. Furthermore, the system is arranged to close the communication circuit at either end only when there is a fault on the power system, so that under normal conditions both ends of the communication circuit are open irrespective of whether or not load is being carried over the line. Stated another way, the directional relay system is inherently a fault detector as well as a directional detector. This is necessary, as will be shown later, to secure the most reliable operation from the communication system.

There are several directional relay arrangements which are suitable for use with this protective scheme. In the case of protection against phase faults, a single directional relay of the polyphase type or else 3 single-phase units may be used. If the line is provided with directional phase or ground relays for back-up purposes in addition to the overall protection, the directional elements of these relays may be used to control the overall protection, provided the contacts of these directional elements are placed in the trip circuit of the relays as is often the case. When single-phase directional elements having true or approximate wattmeter characteristics are used, it is necessary to associate an instantaneous overcurrent relay installed in the same phase with each directional element. The contacts of the directional and overcurrent elements of each phase are connected in series and the 3-phase groups connected in parallel. It is possible to have an unsymmetrical fault behind the group of directional elements of such a nature that one of the single-phase directional elements will reverse and close its contacts. The phase on which this can happen will be carrying a relatively small current, however, so that the introduction of the overcurrent element set at the proper value will prevent the group of directional elements from closing the control circuit of the protective scheme.

These overcurrent elements also prevent this control circuit from being closed at either end of the line due to the flow of load current, which is necessary for the proper operation of the scheme. When a polyphase directional relay is used, it must either be provided with voltage restraining coils which will hold the contacts open under load conditions or else be supplemented by a set of overcurrent elements to accomplish the same result.

Some single-phase directional elements are provided with voltage restraining coils so that their contacts are normally open under flow of load current and have operating characteristics such that the use of additional overcurrent elements are not necessary if they are used to control the protective scheme.

The directional elements of ground relays are normally open so that an overcurrent element is not strictly necessary, but the use of such an additional element may be considered desirable to reduce the sensitivity of the device.

It has been assumed so far that there is a source of fault current supply at each end of the line. The system can be made to function in case there is not a source of fault current supply at one end by replacing the directional relay at that end by an equivalent system such as an instantaneous overcurrent element and an instantaneous undervoltage element in each phase. The first element is circuit opening on overcurrent and the second element is circuit closing on undervoltage. The contacts of the 2 elements are connected in series. Normally the control circuit is open due to the presence of voltage on the transmission line, but if the phase under consideration is faulted the voltage will drop causing the voltage element contacts to close. If this condition is caused by a through fault, however, the current element contacts will open before the voltage element contacts can close so that the control circuit will not be closed. If the fault is on the line the current element contacts will not open, so that the control circuit will be closed as soon as the voltage element contacts have closed. A somewhat similar arrangement can be made to secure correct operation on ground faults.

Other possible arrangements suggest themselves. When there is sometimes, but not always, a source of fault current supply at either end of the line, it is

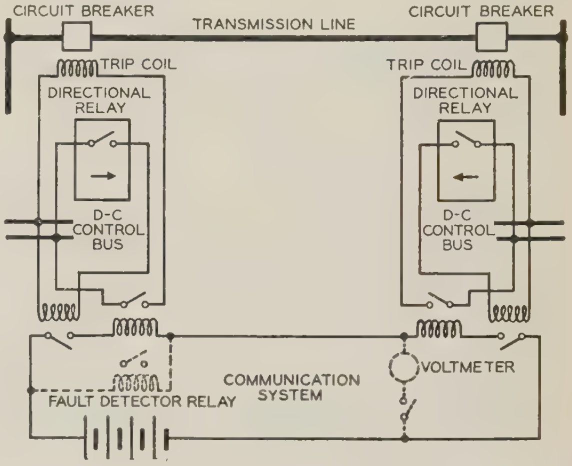


Fig. 1. Communication system used to obtain overall protection by directional comparison

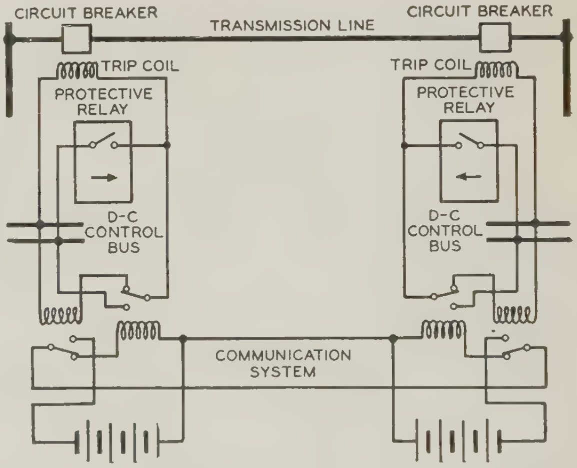
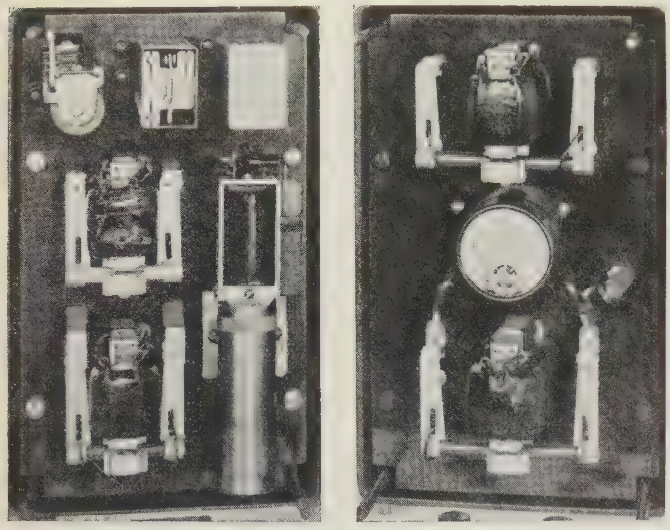


Fig. 2. Communication system used to obtain transferred tripping

necessary to use both a directional relay and the above combination of current and voltage elements, or some equivalent arrangement.

Under certain conditions, the phase relay system may operate incorrectly at times of ground faults. When this can occur it is necessary to provide both a phase and a ground relay system and to interlock the 2 systems so as to render the phase relay system inoperative when there is flow of ground current.



Figs. 3 and 4. Assemblies of d-c telegraph relays used by Philadelphia Electric Company

Fig. 3 (left) shows relay assembly for battery station, consisting of circuit closing, tripping, fault detector, lockout, and oil dashpot relays, the latter giving a time delay to the lockout function

Fig. 4 (right) shows relay assembly for distant station, consisting of circuit closing and tripping relays, and voltmeter for checking continuity of the circuit. Insulation between telegraph circuit and station control circuits is designed for 10,000 volts

Transferred Tripping

With transferred tripping the communication system is used as an adjunct to a standard relay protection scheme either of the balanced current or step-by-step distance type in order to insure instantaneous tripping of both ends of the line under all conditions of faults occurring on the line. It is assumed that the relay protective scheme is of such nature that instantaneous tripping may be secured at at least one end of the line for any type or location of fault on the line. The communication system, arranged as shown in Fig. 2, merely serves to trip the other breaker as soon as either breaker trip coil is energized.

While this method is similar to the directional comparison method in that instantaneous tripping for all fault positions on the line is obtained, its selectivity in the case of external faults depends upon the selectivity of the relay protection scheme at either line end. This relay protection scheme will be more complicated and costly than the directional relay system required by the directional comparison method. On the other hand, the line is completely protected, even if the communication system fails to operate. The directional comparison method will probably be the more desirable in the majority of cases, although transferred tripping may be useful in certain instances where selective timing relays are already installed or where there is an objection to the use of a communication system as a component part of the first line of defense. Either method requires a communication system of substantially the same form, which must be as fast and as reliable in operation as possible.

Types of Communication Systems

The types of communication systems which are adaptable to this service are the d-c telegraph, the low-frequency rectified a-c pulse telegraph, carrier-current, and the voice-frequency telegraph. These systems will be described as applied specifically to the directional comparison method only, but the modifications required to adapt them to transferred tripping are self-evident.

D-C Telegraph

The fundamental circuit of the d-c telegraph system has already been shown in Fig. 1. With this arrangement, however, it is evident that a short circuit on the telegraph line will cause the line to be tripped at the end at which the telegraph battery is located if the directional relay system at that end is closed. This would result in an incorrect operation in the case of a through fault on the power system. For this reason, it is necessary to provide the telegraph circuit with a monitoring system which will detect faults on this circuit and automatically render the relay system inoperative before a through fault is likely to occur. This can be done by normally energizing the telegraph circuit through the coil of a sensitive fault detector relay as shown in dotted lines in Fig. 1. This fault detector relay may be arranged to lock open the telegraph circuit and give an alarm.

Whenever a through fault occurs on the power system in such a position that the directional relay system at the end away from the battery will close, this will close the telegraph circuit through the fault detector relay. It is therefore necessary that the fault detector have sufficient resistance to keep the flow of current below the operating point of the tripping relay at the distant end; and since the fault detector relay will operate, it is necessary to introduce a time delay in the lockout feature so that such a system fault can be cleared before the telegraph circuit locks out.

The telegraph circuit can be checked for continuity at any time by introducing a high resistance voltmeter at the end away from the battery, as shown by the dotted lines in Fig. 1. It is possible to secure an automatic indication of continuity by substituting a sensitive undervoltage alarm relay for the voltmeter, but this relay must have a sensitivity greater than the fault detector relay and sufficient resistance

to keep the normal flow of current below the operating point of the fault detector relay.

The conventional d-c telegraph circuit employs a single wire with ground return. While this arrangement is theoretically suitable for use in this connection provided the grounding points of the telegraph circuit are made at considerable distances from the power system grounds, it is not in general as safe or reliable for this particular service as the 2-wire or metallic circuit grounded at only one point.

Low-Frequency Rectified A-C Pulse Telegraph

In general, 2 d-c telegraph circuits would be required for the protection of 2 parallel transmission lines. Although various modifications employing polarized relays and additional batteries may be made which permit the use of a single telegraph circuit, these arrangements are complicated and will not operate if both transmission lines are simultaneously faulted. In order to overcome these difficulties the arrangement shown in Fig. 5 is suggested, employing an alternating emf of low frequency and suitable rectifying units acting as valves to control the flow of current through the tripping relays. The telegraph equipment of the upper line is operated by the postive half cycles of the voltage furnished by the alternator, while the equipment of the lower line is controlled by the negative half cycles. The use of low frequency is desirable to minimize the line reactance. The tripping relays must be designed to hold in over the opposite half cycles during which they receive no current. A standard 20-cycle ringing machine, continuously driven by a d-c motor from the station control battery would serve as the alternator, and standard copper-oxide rectifying units are suitable for use as valves. A d-c monitoring system may be readily adapted to the circuit.

This is a pulse system and must not be confused with an a-c system. Care must be taken to prevent the current pulses from setting up counter emfs in the circuit and for this reason transformers cannot be used as coupling or line insulating devices.

Carrier-Current

A carrier-current system of overall protection of transmission lines against ground faults has been in operation on the Southern California Edison system[3] for several years. In the manufacturer's original design of carrier-current protection, the relative instantaneous directions of the residual current at each end of the line were compared.[4] This arrangement had several disadvantages. As a result the present form of this equipment offered by the manufacturer is based upon directional comparison of fault current flow and therefore is applicable to protection against all types of faults.[5,6]

The general arrangement of this equipment is indicated in Fig. 6. The line is equipped at each end with a carrier-current transmitter consisting of a vacuum tube master oscillator and power amplifier and a simple single tube receiver suitably coupled to 2 conductors of the transmission line. Since the transmission line is used as the communication channel, a short circuit between the conductors forming this channel would render the communication system inoperative. It is therefore necessary to arrange the equipment so that the signals transmitted are used to prevent, rather than to initiate, the tripping operations. This in turn requires the installation of traps in the transmission line to prevent external faults from interfering with the communication. The signal transmission at each end of the line is initiated by an instantaneous directional relay (transmitter starting relay) which is directional toward the bus. The back contacts of this relay on opening put the master oscillator of the transmitter into operation. A second directional relay (tripping relay) which has a slight time delay and is made directional toward the line initiates the tripping operation unless a signal is received before its contacts have closed. If there is a fault on the line, therefore, no signals will be transmitted or received and the tripping operations are allowed to take place. In the case of a through fault, the tripping directional relay starts to operate at the end where power is flowing into the line, but a signal

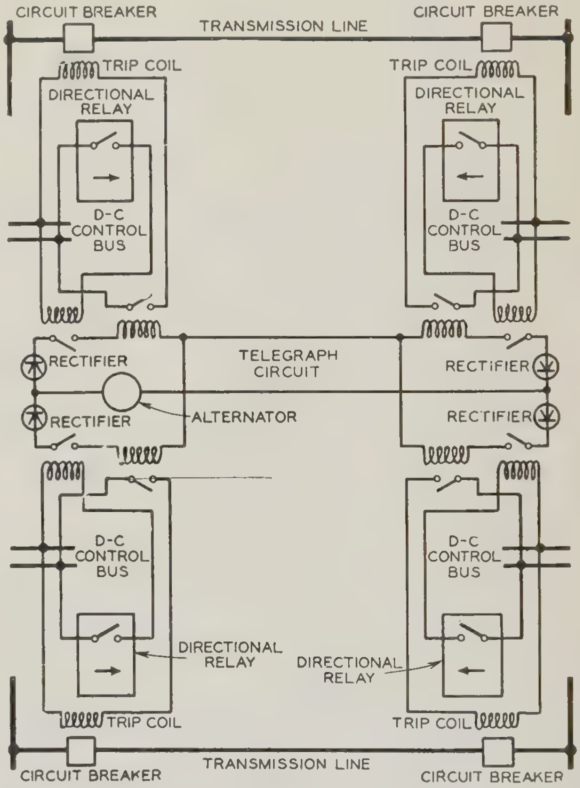


Fig. 5. Low frequency rectified a-c pulse communication system for the protection of 2 transmission lines

is instantly transmitted from the other end, and is received in time to open the trip circuit before the contacts of the tripping direction relay have closed.

A single frequency (100,000 cycles) is used for transmission in both directions and the transmitters and receivers are tuned to this frequency. The

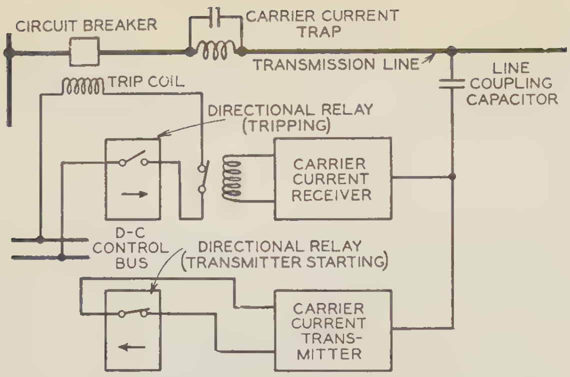


Fig. 6. Arrangement of carrier current communication system

filaments of the vacuum tubes are kept energized continuously, and the slight time delay required in initiating the tripping operation can be made as low as $3^1/_2$ cycles with assurance of getting positive lockout on through faults.

Since the failure of either a transmitter or receiver equipment can produce tripping in the case of a through fault, some means of automatic supervision is necessary. This takes the form of a periodic timing device at each line end that momentarily energizes the transmitter. The associated receiver, being tuned to the same frequency, should respond and operate the receiver relay. The device is so arranged that an alarm is given in case the receiver fails to operate. By proper synchronization and arrangement of the supervising devices at the line ends, it is possible to check the overall transmission between stations and automatically to lock open the trip circuit at either end in case a signal is not received from the other end at the appointed time.

Voice Frequency Telegraph

A system of voice frequency telegraphic communication suitable for the transmission of 12 messages simultaneously over a telephone circuit is in use by the American Telephone and Telegraph Company.[7] This system operates on the principle that a different frequency is used for each telegraph channel. The 12 frequencies are superposed on the telephone circuit and separated at the receiving end by band pass filters, after which each frequency is rectified and permitted to operate a receiving telegraph relay.

This sytem may be readily adapted for relay communication as shown in Fig. 7. When the directional relay at either end of the transmission line closes, it permits the voice frequency transmitter associated with it to transmit a signal of a definite frequency over the telephone line. The receiver system at the other end of the transmission line is tuned to respond to this frequency and to this frequency only. The system is arranged to trip the line when a signal is received at either end at the same time that the directional relay at that end is closed. The transmitter at one end of the line must be prevented from operating the receiver at the same end; this may be done by using 2 frequencies for each transmission line or by substituting a bridge transformer for the repeating coil shown on the diagram. Such arrangements will keep the transmitted frequency out of the receiver so that both transmitters associated with one transmission line can operate at the same frequency thus permitting the protection of 12 transmission lines with a single telephone circuit.

A suggested design of the voice frequency telegraph equipment incorporating the transmitter and receiver in a single unit operative from a 250-volt power station control battery is shown in Fig. 8. The filaments of the vacuum tubes are continuously energized and the equipment is put into operation by the directional relay which applies plate potential to the tubes.

Selection and Coordination of Communication Systems

The selection of the type of communication system best suited for the protection of a given transmission line involves a great number of considerations, many of which are beyond the scope of this paper. In general the type of relay communication employed should be closely coordinated with the type of telephonic communication used between the power stations involved, utilizing, if possible, existing equipment.

In the case of the carrier-current system, failure of the communication equipment will not interfere with the tripping of either end of the line for faults on the line, but may result in the tripping of a line end on through faults in one direction, depending upon what part of the communication equipment fails. Substantially the reverse is true with the other systems, since the failure of the communicative equipment renders the protective system inoperative. Where suitable backup protection can be provided

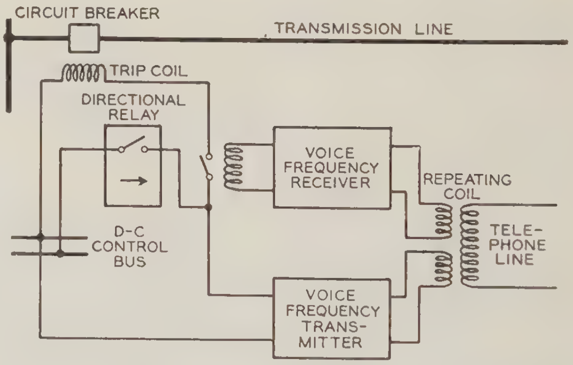


Fig. 7. Arrangement of voice frequency communication system

it is generally more desirable to have equipment failure render the primary protection inoperative than to have it make the system susceptible to inselective operation. However, many exceptions to this principle will be found. With proper supervision of the equipment, the probability of experiencing serious system trouble as the result of the failure of either system is extremely small.

There is little choice between systems in respect to their speed of operation. The operating time of the carrier-current system has been given as $3^1/_2$ cycles, but this time can probably be reduced slightly where it is necessary. Contrasted with this, we have the sum of the operating times of a directional relay and a tripping relay which determines the operating time of the other systems. This time cannot be made materially less than $1^1/_2$ cycles. With the high speed breakers available at present having operating times in the order of 8 cycles, the difference in operating times of the communication systems is negligible.

The carrier-current system is not adaptable to the protection of cable lines due to the fact that the cable capacity furnishes an effective short circuit across the line and thus prevents the passage of the signals.

Where telegraph or telephone circuits are used, these circuits will, in the majority of cases, be leased from the local telephone company. In this event, certain restrictions are placed on the circuits as to the magnitude of the voltage applied and current circulated; and also, in certain cases, a high degree of insulation strength will be required between the communication circuit and the power station ground or control circuits.[8] These conditions may be complied with by the suitable design of the communication equipment in the power stations.

In order to prevent interference with these circuits in the telephone exchanges through which they pass, special tagging may be employed, such as has become the custom with radio broadcasting circuits. The use of monitoring devices will indicate at once the occurrence of trouble on the circuit and the modern telephone plant is so equipped that most trouble can be rectified in a very short time after it has been brought to the attention of the telephone company.

The d-c telegraph is the simplest and probably the most reliable form of relay communication, but as it requires a separate circuit for each transmission line protected, the cost of leasing these circuits may become an insurmountable item. The low-frequency rectified a-c pulse telegraph permits the protection of 2 transmission lines between the same power stations with a single communication circuit. While this system is in the experimental stage and will probably be limited to use with relatively short communication circuits, nevertheless it offers possibilities for reducing the cost of the protection. The disadvantage that the failure of the communication circuit will invalidate the overall protection of 2 lines is not particularly serious if the circuit has a sufficiently high degree of reliability.

In the case of a power system having a number of interconnected stations within a relatively small area, a single telephone circuit might be run from each station to a central point, and all of the interconnecting transmission lines be given overall protection by use of the voice frequency telegraph. While such an arrangement has not been tried, there should be no particular difficulty in constructing voice frequency telegraph units along the general lines indicated in Fig. 8, which would be comparable in cost and reliability to the higher frequency units utilized with the carrier-current system. Under such conditions, the cost of carrying the few telephone circuits required might be considerably less than the investment in transmission line coupling devices and traps required by a complete carrier-current installation.

When the power stations terminating the transmission line are directly connected by one or more telephone circuits, it is often possible to superpose

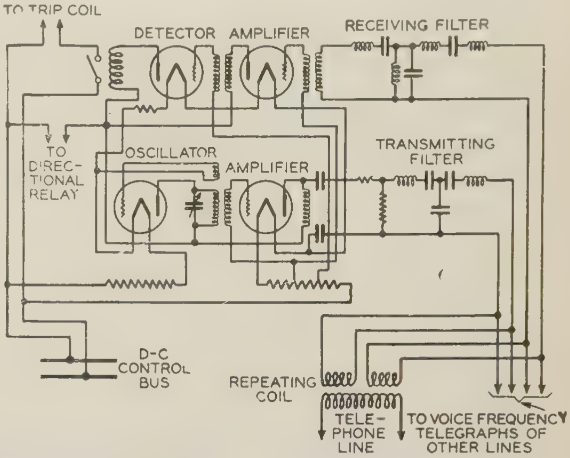


Fig. 8. Details of voice frequency telegraph communication equipment

either the d-c or low-frequency rectified a-c pulse telegraph on such telephone circuits. Such superposition is accomplished by simplexing or compositing.[8] With respect to circuit facilities leased from telephone companies, it is the practice of certain of these companies to charge for their facilities on a channel basis. Where a talking channel and a superposed telegraph channel are both provided, the charge for each channel would be applied.

When telemetering or supervisory control is used between the power stations it may be possible to use the same circuits for relay communication as well, providing the two systems can be properly coordinated.

Undoubtedly, there are other communication systems or arrangements suitable for relay purposes which have not been mentioned, but the systems which have been discussed appear to be the most readily adaptable. In the final analysis the communication system is the heart of the protective schemes described. Communication is an art somewhat apart from relay engineering, and it is hoped that the few principles contained in this article may be of some interest to those more familiar with this art in providing facilities suitable for relay purposes.

Conclusions

The following conclusions may be drawn from the foregoing discussion:

1. Overall protection of transmission lines may be accomplished by comparing the relative directions of fault current flow at the terminals of the line. This arrangement resolves into a directional relay system at each end of the line interconnected by a communication system.

2. Directional comparison secures all the advantages of differential

protection; and by substituting a communication system for a-c pilot wires, results in a simpler, more reliable, and less costly installation.

3. The directional relay system required utilizes standard relays which in certain cases may be component parts of the normal or backup protection of the line.

4. A communication system can also be used to link the trip circuits at the ends of a transmission line provided with any conventional protection, thus insuring the simultaneous tripping of both line ends for all fault positions.

5. Several types of communication systems are readily adaptable for relay purposes. The choice of the particular system to be used is governed by local considerations, particularly in regard to possible coordination with other telephonic, telemetering, or supervisory control circuits employed as adjuncts of the power system.

6. The relay communication system is the heart of the protective scheme. The widespread use of transmission line protection by the methods outlined lies in the availability of communication facilities which are reliable and which may be secured without undue cost.

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A New Electronic Recorder

There has been developed an electronic recorder applicable for such feeble quantities as thermal emfs, vacuum tube currents and voltages, light intensities, and magnetic strain gage readings. A description of this recorder, its characteristics, and fields of application are described in this article.

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THE MOVING of a pen across paper takes a great deal more power than is available in the coils or circuits of ordinary indicating instruments. For certain measurements, only the "highly sensitive" type of instruments is applicable. The friction of a pen across paper is from 100 to 1,000 times as great as the friction in jeweled movement bearings. Thus indicating instruments of the microampere class have been available for some time, in contrast to which conventional recorders have been of the milliampere class as exemplified in d-c d'Arsonval type instruments.

To record low energy values accurately, it is essential that the recorder consume negligible power in comparison to the value being recorded. To this end, schemes of recording making use of the relay principle have been in use both here and abroad, but in every case relay type recorders of the mechanical type have definite limitations in speed, power consumption, and sensitivity. Contacts in conventional type recorders limit sensitivity by requiring in themselves considerable pressure to operate.

The radio receiver picks up a microscopic amount of energy from the air and amplifies it to concert volume. Would not electronic means therefore afford a similar solution to the problem of recording low energy values? This led to a thorough investigation of the various electronic methods which would accomplish the result. Most of the possible methods studied had certain limitations and disadvantages in that they were either limited to a-c measurements or made use of photocells, optical systems, or contacts which require maintenance or have certain limitations as regards ambient temperature.

This general investigation has advanced to the point of finding a means, free from obvious disadvantages and limitations, which seems sufficiently complete and flexible to answer the requirements. It promises a practical method of obtaining accurate record charts from the action of a simple indicating instrument. It depends upon the use of an additional coil mounted on the moving element of the measuring instrument. This coil does not add any appreciable work for the measuring element to perform; therefore, the accuracy or the torque requirement is not changed. This coil is used as a detecting or pilot coil and is placed in the field of a stationary a-c electromagnet. The object of the pilot coil is to detect the position of the measuring element with respect to the electromagnet. A duplicate of this coil is mounted on the recording mechanism and arranged to operate in the field of a similar electromagnet excited from the same a-c source. The relative position of these pilot coils is compared and controlled by their relative action on an auxiliary circuit. The current in this auxiliary circuit is amplified to give power sufficient to drive a high torque pen driving element.

The electronic recorder consists essentially of:

1. The primary, or measuring element which may be any usual type indicating instrument mechanism.

Full text of "New System of Recording Using Electronic Means" presented informally at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933. *Not published in pamphlet form.*

2. The pilot element attached to the measuring element.

3. The pilot element at the pen mechanism.

4. The motor element for driving the recording pen and for carrying the second pilot element coil.

5. An amplifier for furnishing reversible driving power to the pen motor.

The principle of operation of the recorder, illustrated in Fig. 1, may be understood by a study of the diagram, Fig. 2, and the following explanation:

The primary element, which may be any electrical instrument mechanism, or measuring mechanism whose position depends upon the quantity being measured, is mechanically connected to a pilot element which comprises a moving coil mechanism rotatable in an a-c field. This field is provided by a stationary electromagnet connected to an auxiliary controlling circuit. The moving coil of this pilot coil is connected in series with the moving coil of the duplicate pilot element which is mechanically connected to the pen driving motor as shown in the schematic diagram. The stationary fields of both pilot elements are connected in parallel to the same a-c source. The moving coils of the pilot elements are connected in series opposing each other. When these coils do not occupy the same relative positions in the a-c fields, the voltages induced in the coils are not equal so that the output voltage at the terminals of the pilot moving coils is of a value depending upon the magnitude of this difference. This voltage is of the order of 50 mv per deg deflection. The output of these coils is connected to the grid of the amplifier tube of the power amplifier unit. The a-c output of the amplifier is the same frequency as the pilot element excitation.

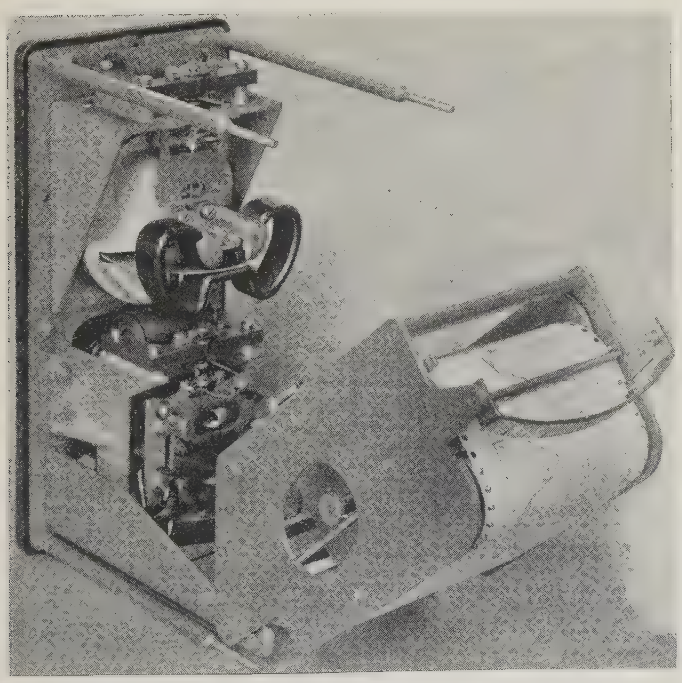
Fig. 1. New electronic recorder with cover removed and with chart carriage swung forward for changing records or winding

The complete recorder shown above without amplifier may be mounted in a removable pressed steel case with glass front. The case is 5 1/2 in. wide, 12 in. high, and 9 in. deep

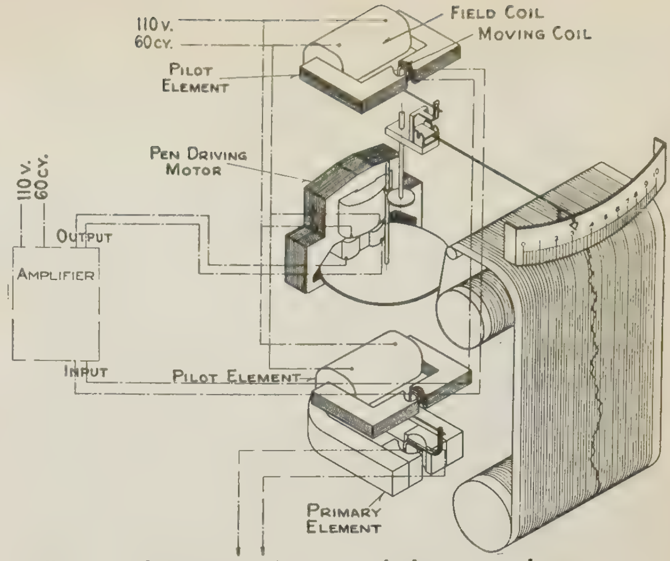

Fig. 2 Schematic diagram of the new electronic recorder

The pen driving motor is essentially a 2-phase motor of which one phase is continually energized from the same source of power as the pilot element electromagnet coils. The phase position of the current in the other phase of the motor is determined by the relative positions of the pilot coils which determine the polarity and magnitude of voltage of the amplifier grid and as a consequence the a-c output of the amplifier. With the second phase of the pen driving motor connected to the amplifier output, the motor will turn in a clockwise or counterclockwise direction at a speed proportional to the difference in pilot coil positions. This results in a proportionate response action of the pen motor. It should be noted that this proportionate response action makes antihunting or special damping unnecessary as contrasted to the usual relay type recorder, and makes speed of response proportional to the deflection.

This overcomes the difficulty of previous relay type recorders in which the speed of response cannot be made as great as in corresponding indicating instruments without introducing hunting. Therefore, the action of the new recorder can be made as fast as that of the primary element.

The pen motor turns in one direction or the other until the difference in pilot voltages is zero, thus using a "null" method. Therefore, it is free from any errors which might result from aging or change in characteristics of the vacuum tubes which would result during their normal life. Usual decreases in emission or amplification factor result only in a decrease in the speed of response which is so small as to be unnoticeable for normal changes. Changes in control voltage within rather wide limits produce no noticeable effect. This is also true for changes in control frequency and wave form. Temperature changes produce no error. Stray fields affect both pilot coils equally so that no errors result. The additional energy required for the primary element to drive the pilot coils is that required to overcome the torque of the conducting springs. The torque of these springs is less than a tenth of the torque of the lowest reading microammeters. Furthermore,

the pilot coil torque is a constant value which may be compensated for in calibration.

The torque gradient of the recorder is approximately 2 cm-g per deg at normal control voltage. This corresponds to the torque of a 720 cm-g spring and is 5 to 10 times the torque gradient of conventional direct acting recorders. This greater torque gradient is obtained without increasing the weight or inertia of the pen driving mechanism over that of direct acting recorders. In fact, the motor element is lighter and has less inertia than a direct acting element.

Changes in control voltage change the torque gradient of the instrument to a certain extent. A 20 per cent decrease in voltage reduces the torque gradient to 0.75 cm-g per deg. Even at this reduced voltage the torque gradient is higher than in conventional direct acting recorders. The accuracy of the pen positioning is not effected by the reduced torque gradient. This is to be expected as the change in control voltage affects both pilot elements equally. An increase in control voltage increases the torque gradient, but to a less extent.

Decreased output of tubes due to aging has the same effect as a decrease in control voltage; namely, a reduction in torque gradient. A large decrease in response is an indication that new tubes are required.

Under normal conditions it requires one second for the pen to travel from zero to full scale with an overshoot of approximately 2 per cent. By increasing the time to 1.25 sec, the recorder can be made dead beat.

This instrument will record d-c millivolts and microamperes at energy levels of 4 or 5 μw. A d'Arsonval mechanism in combination with a rectox rectifier makes possible the recording of alternating currents with full scale values as low as 0.5 ma. Alternating voltages can be recorded in the same manner with one volt full scale and a potential circuit resistance of 500 ohms per volt. This recorder should find innumerable applications in the recording of such feeble quantities as thermal emfs, vacuum tube currents and voltages including photoelectric currents, recording light intensities and magnetic strain gage readings whose deflections represent deformations of the order of thousandths of an inch. Narrow range frequency indications or any alternating or direct current of lower energy than it is possible to record by conventional means may be recorded.

The recorder is designed in this particular line for panel mounting on 6 in. centers. The amplifier or power unit is arranged in a separate case which mounts on the back of portable recorders or at the rear of the switchboard for switchboard type recorders. The pressed steel case is removable, leaving the complete mechanism free for inspection and adjustments, changing record charts, adding ink, or winding the clock. The chart carriage is hinged at the bottom near the front so that the carriage swings forward to clear adjacent recorders when winding the clock or changing record charts. While in the normal vertical position the chart mechanism is securely locked by a latch which may be released by a small lever allowing the mechanism to swing forward against a stop.

It is worthy of note that all the elements of the new recorder are time tried and proved mechanisms. The primary element is a standard electrical indicating instrument mechanism. The pilot elements are standard d'Arsonval type mechanisms operating in laminated electromagnets. The pen driving motor is practically a standard induction type watthour meter. The amplifier or power unit is developed using latest available vacuum tubes and is designed for long life and reliability.

Hot Cathode Electronic Tube Designations

NAMES of some of the more common types of hot cathode tubes used for control and power purposes are given in Table I. This table also includes the trade names employed by a few of the manufacturers but should not be interpreted as a complete tabulation for all manufacturers. No attempt has been made to include the many varieties of radio tubes.

In brief, the distinguishing characteristic of the high vacuum tube is high space charge effect, or relatively high voltage drop. The gas or mercury vapor and "high pressure" tubes are characterized by low space charge effect and low voltage drop.

This information was included in a talk on "Electron Tubes for Control and Power Purposes," presented by W. S. Hill, General Electric Company, New York, N. Y., before the power group of the Institute's New York Section, Nov. 29, 1932.

Table I—Hot Cathode Tubes

	Number of Electrodes				
	2		3	4	5
General designations	Diode (Fleming valve)		Triode (Audion, thermionic amplifier)	Tetrode (Screen grid)	Pentode
Control	Electromagnetic	None	Electrostatic	Electrostatic	Electrostatic
Tube Names					
Vacuum	Magnetron[1]	Kenotron[1]	Pliotron[1]	Pliotron[1]	Pliotron[1]
		Rectifier[2]	Amplifier[2]	Amplifier[2]	Amplifier[2]
Gas or mercury vapor		Phanotron[1]	Thyratron[1]	Thyratron[1]	Thyratron[1]
		Rectifier[2]	Grid-glow[2]	Grid-glow[2]	Grid-glow[2]
"High pressure" tubes		Tungar[1]			
		Rectigon[2]			

1. Designation of the General Electric Company.
2. Designation of the Westinghouse Electric and Mfg. Company.

Editor's Note: Coincident with the preparation of this item, the appointment of a committee was authorized to study the matter of designations of electronic devices. (See item in "Standards" department of this issue, p. 208.)

Evolution of Society as Influenced by the Engineer

The influences of the engineer on society in general are outlined in the following address, which Doctor Merriam presented before a recent meeting of the A.I.E.E. In addition to pointing out the debt of society to the engineer, Doctor Merriam indicates methods whereby the engineer might be of still greater use in the development of a well-informed and intelligent society.

By
JOHN C. MERRIAM President, Carnegie Institution of Washington, D. C.

IT MUST BE with humility that one concerned with general science undertakes to address a group of acknowledged experts in a field of technical study and operation. Therefore, avoiding the technical phases of the problem, this statement concerns itself with the relation of engineering on the one hand to science, and on the other to human problems illustrated in organization and evolution of society.

It is the purpose of this address to refer specifically to the manner in which engineering opens the road to that kind of a social organization of which we dream, and in which we pride ourselves, whether or not we are correct, on the assumption that our present form of social-governmental organization is a success.

What is said here is predicated upon the idea that there is possible a development of the individual to higher and higher levels of effectiveness and enjoyment or usefulness, in whatever way you may wish to define this situation. These statements also are predicated upon the assumption that society in the broad sense is on a road of development leading to more effective means of organization that in time will produce a better environment in which to enjoy and to accomplish.

As to the relation of science to engineering, the statement can be made that science, which may lay large claim to use of the words creative and constructive, is in general not a creative activity. The scientist is commonly discoverer and philosopher. He may develop, he may reorganize, but in the main he is a discoverer of things which already exist.

On the other hand, the engineer, who is thought of as turning things over and using the results from the work of science, may become a creator and produce that which has not previously existed.

Science is indebted to engineering in that while science may give to the engineering group much that is used for development, the furtherance of science itself is dependent upon what is often referred to as the financial status. One of Huxley's significant remarks was that ultimately everything resolves itself into terms of finance. The scientist does not commonly finance his own investigations.

In looking over the story of mankind one may incline to the view that science, in the natural history sense, was the first form of organized knowledge. There was a classification of snakes that should not be allowed to bite, and of plants that should not be eaten and of those that are good for food. Early in the Paleolithic Period there probably was an organization of knowledge not so very different from that existing today for these materials.

Then came a time in which the problem shifted from keeping out of the range of saber-tooth tigers and snakes, and men occupied themselves more largely with questions concerning how people could get along together. Social organization with government then became the greatest question. Government was perhaps the most important task. It is not yet a complete success, and yet it may be the largest single accomplishment of mankind up to the present day. It is a difficult work but, as badly off as we may be, it is a long way that we have come.

This organization of mankind in government has made possible development of your great engineering programs. Without it engineering could have gone only a short distance. Engineering in turn has placed its resources at the disposal of many kinds of activities, among them the interests of the scientist. Science is now attempting to return to engineering what it receives from this support, made possible in turn by social organization or government in the broader sense.

It is not intended to suggest that science is unimportant. Science is not only significant, but alluring. Adventuring in the field of research is, at the moment, the greatest opportunity that the universe offers. Any one who wishes to penetrate the veils covering the spiral nebulae, or desires to see inside of the sun or the other side of the moon or the various aspects of theories concerning the expanding universe, has an interesting task.

From one point of view the engineer turns the blocks that the investigator discovers into things that are useful in life, in maintaining life, or extending its enjoyment. From the point of view of a scientist the engineers may come nearer than any other group to being what was just referred to as a creator, in that they can produce things which the universe has never known, and continue to form useful combinations and recombinations.

Not everything done through engineering has its immediate human value in uplift. With all the tremendous contribution made by the radio, the music is not sweeter or better, nor is the enjoyment of music greater than it was before that wonderful invention came into use. Many are being trained to music, but is the training comparable to

Essentially full text of an address "Evolution of Society as Influenced by the Engineer," presented at the conclusion of the Edison Medal presentation during the A.I.E.E. winter convention, Jan. 23–27, 1933. *Not published in pamphlet form.*

that received when we tried to construct music or to use it for ourselves?

Also, when we drive through the country in high speed automobiles it is not certain whether we see more, or less, than in the days when we walked. But this statement must not be left with the suggestion that these contributions do not add greatly to enjoyment of living, and to the profit and to the advancement of the individual and of society.

As to society itself and its needs, no attempt is made here to discuss the great social questions at the present moment. It is worth noting, however, that society has passed through many evolutionary stages, and that at the present moment it is probably faced with greater and more difficult problems than at any previous stages in world history. This is due partly to the fact that the world's interests have been tied together by means that developed out of the operations of the engineer. If the world were to go to crash because this situation has developed, would the engineer be in any sense responsible for the difficulties? If, on the other hand, out of these complications there should arise a situation better than any we have faced in the past, would the engineer be said to have assisted in lifting us to a higher level of development in social organization?

It is not planned to catalogue specifically the difficulties in these great social questions. There is, however, reason for stating that present situations are in large measure due to 3 negative principles, which are: ignorance, bad judgment, and selfishness. The more discussion there is on world problems the clearer it is that the element which is lacking first of all is knowledge of the facts. Judgment is merely the laying out of facts to determine the direction in which they point. The greater the number of facts, the more difficult it is for the average person to form a judgment as to what the situation really means.

When you add the element of self-interest, it becomes extremely difficult with lack of facts, and inadequacy of judgment, to develop a situation in which the great problems of our own country or of the world can be solved. One may refer either to economic questions or to those that concern government.

And now, returning to science, apparently one of the things which the world needs most at the present time is an attitude toward these situations representing a combination of the point of view of the scientist who needs facts, and the engineer who indicates that these facts must have an orderly arrangement with reference to each question considered. If every citizen of this country could approach each of the great questions which we face at the ballot box or elsewhere, with an attitude of mind requiring facts and their orderly arrangement, it would aid greatly in solving our major problems for the immediate future.

As to the question of adjustments in society: at the moment the world apparently has reached a stage in which out of the various needs in life those which have to do with what we sometimes call maintenance, that is, the securing of food and shelter and clothing and such requirements, can be met without use of all the labor in the world. We have produced means of communication, by train, auto, telegraph, telephone, which make it possible for us to keep in touch over the world. But, with all these means of finding where work is and how to reach it, there are millions upon millions of people who have nothing to do.

The central point to be made is this: We have, whether correctly or not, set up a program of organized society with the assumption that the people will have something to say about their government. No one knows what the result will be. It may be that a people governed by a dictator or a monarch, or by a manager, are in a more satisfactory situation than the one we now occupy. But it is probable that through future generations the people will wish to have something to say about handling the organization which controls them. There can be no doubt that for conduct of such a government we shall require a high level of education, understanding of great national questions, and extraordinarily clear human judgment. Is it possible that shortening of hours of labor is the thing which will open the way for development of an educational program by which the average citizen can form fully adequate judgments regarding the person to be elected as ruler, or concerning questions upon which we wish to express opinion?

Can it be that the situation we meet in the world today is in a manner what is needed to make possible the kind of a government we would like to have? It is doubtful whether democracy can succeed fully without a level of understanding of such problems higher than has yet been attained in any country trying out this system. If so, we must proceed to that kind of an adjustment in which the opportunity offered may be used in some part to make self-government possible.

Perhaps we are coming to the point where we can make the adjustment. Those who are now out of employment may not be the ones to take over the new tasks for education or for improvement. But possibly they can be cared for in the reorganization.

We must continue intensive study of how there can be concentrated in life of the youth the things essential for his beginning education. The young person might spend less time upon this concentrated effort to amass a heap of information before taking up the life he is to lead. Instead of considering his graduation the terminus of education it should be near the beginning. In continuing education of the adult we do not care especially to assimilate masses of facts, but wish to know clear realities in their normal setting. Such a development may be expected in the education of the individual that he will grow in every week of life.

This is then a problem for the scientist, for the educator, for the student of social sciences, and it is especially a problem for the student of government. With all the scientist does to prepare the way for the great things of the engineer he is not in a position to realize in everyday life the whole result of his work. The engineer has a unique opportunity, not just to control, but to build and to guide in the direction under discussion.

Unity of knowledge, diversification, and specialization are important factors. There must be

students of atomic physics, there must be paleontologists, and there must be students of astronomy, but they all represent parts of one great field of knowledge. There must be those who write poetry, and those who preach, and those who teach us the rudiments of art, in order that we attain the most from life as we live it.

We have specialized so far in science that we forget sometimes the relation between work of the biologist studying chromosomes, and that of the physicist working with structure of the atom. We are now beginning to find that great advances in science may come through keeping these types of endeavor so related that the thing needed may be found when required.

The engineer can aid greatly by keeping watch over the scientist, perhaps to see that he keeps on with his task, perhaps to make sure that he receives help when needed. The engineer has a great responsibility in the study of the social problem as related to government. Perhaps he has also a responsibility as a preacher of good doctrine. Whatever has to do with clear thinking and good ideals, may not be separated from life as lived. Possibly we need good preachers among the engineers and good engineers and scientists among the preachers.

A responsibility rests upon the scientist to have some understanding of what the influence of his contribution is upon civilization, upon society. A similar moral responsibility rests upon the engineer to see in what direction his developments are leading us, and the way to formulate such social organization as will make the world we are now building safe for the people in it.

Although we are not headed for destruction, it would be very surprising if progress developed at an absolutely even rate. Sometimes a deviation from what appears the normal path is the element needed to make us inquire what the direction really is.

In conclusion, the contribution of the engineer may be said to be something which paves the way for a social condition or situation opening larger opportunity for the kind of a life we really wish to live.

Perhaps we have tended too much to consider alone the things called comforts, whereas we know perfectly well that it is the pleasures of the mind that are greatest and highest and most important to us. This is true whatever our station in life, or the profession in which we engage. It has not been intended here to turn attention wholly toward pleasures of the mind, or intellect, or toward art or religion. However, it must be emphasized that these should not be subordinated in any social scheme which we may build.

The influence of the engineer has been all for the good in its guidance toward straight and orderly thinking, and toward artistic expression. When a program is planned according to an engineering scheme, the parts all fit, and something in it is the central element. That is approximately the basis of art, which is, in general, the statement of things in a manner that will attain perfect clearness as to the special point concerned, and also the relation of that element to all others in the picture.

This does not mean that forthwith all engineers should become artists, or students of social science or of government. Evolution of society is important, and with all that the engineer does to make life comfortable, it may sometime be said that the outstanding contribution of engineers has been in the direction of making possible the social organization that we are striving to realize.

The Atoms as a Source of Light

"Cold" light, the theoretically ideal conversion of electrical energy into light, is still some distance from attainment, being rendered unattainable largely because of a lack of complete theories of the production of light. A summary of the present knowledge in this field and an indication of future possibilities and lines of attack are presented in this article.

By
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IT IS NOT surprising that from the very earliest times man has sought to understand the nature of the rainbow. The beautiful harmony of colors arranged in concentric half rings constitutes a marvel upon which many a fable has been founded. It is, however, only within the past 250 years that science has really been able to interpret this phenomenon, and as a result our whole conception of the nature of matter and energy has been profoundly modified.

The array of colors observed in the rainbow is known as a spectrum, and in the laboratory such a spectrum may be produced by passing a fine pencil of sunlight through a beveled glass prism. It is observed that the beam is thereby not only deflected from its original path, but also spread out into a band which shows all the colors of the rainbow.

The glass prism is the simplest form of spectroscope, an instrument by which the light from any source may be analyzed into its constituent colors. While sunlight and the light from an incandescent filament lamp give a continuous spectrum, that is,

Full text of a talk presented before the General Electric research laboratory colloquium, Schenectady, N. Y., December 30, 1932.

one in which all the colors of the rainbow are present and one color merges insensibly into the next, gases and vapors of metals emit discontinuous, or so-called line spectra. For instance, the spectrum of a mercury vapor lamp shows a number of intense lines in the blue and green regions of the spectrum, but hardly any lines in the red portion. Similarly each of the 92 chemical elements has its characteristic line spectrum which may be produced by passing an electrical discharge through its vapor.

The spectrum of the sun has been mentioned as extending from the red to the violet, but these are not the real limits of the spectrum. Beyond the violet there extends a region, known as the ultra-violet, which is capable of producing therapeutic effects and many chemical reactions, such as the blackening of a photographic film. And at the other end of the spectrum we find the infra-red, or heat rays, such as are emitted by an ordinary radiant heater.

What is the explanation of these different radiations in the spectrum? How are they transmitted to us from any source?

Light is a form of energy and there are 2 methods by which the energy may be transmitted from one point to another. For instance, a baseball pitcher transmits energy to the batter in the form of energy of motion of the baseball, and when the batter strikes the ball, he is again converting the energy of motion of his arms into that of the moving ball. Bullets shot out of a rifle or a stone dropping from a height are other illustrations of a method of energy transmission which we shall designate as the particle method.

We can also transmit energy by a more indirect method. A stone can be dropped into a pond and a disturbance is produced in the water at the point where the stone struck it. This disturbance travels outward as a wave or ripple, strikes a small bit of wood, originally at rest on the surface of the water, and starts it bobbing up and down. Evidently the stone transmitted its energy to the waves on the water, and these in turn transmitted a part of their energy to a bit of wood.

By which of these 2 methods is light transmitted? The physicist of the nineteenth century arrived at the conclusion that light is transmitted through space as a wave motion. Now any form of wave motion is characterized by 2 quantities: the velocity, and wave-length. Instead of the latter we also can use the frequency, which is the quotient of velocity by wave-length.

In the case of light, the velocity is 186,000 miles per sec, and the differences in color observed in the spectrum are found to be due to differences in wave-length or frequency. These wave-lengths are extremely short—so short that 60,000 waves of blue light, or 40,000 waves of red light, are comprised in a single inch, and the complete spectrum of any source of light may consist of vibrations having wave-lengths ranging from approximately 4 millionths of an inch in the extreme ultra-violet to 100 times this length in the extreme infra-red. Further investigations have shown that there are vibrations beyond the ultra-violet which possess wave-lengths from about a 100th to a 10,000th of that of ordinary light, and are known as X-rays and gamma rays. At the other end of the spectrum we pass continuously from heat rays to longer waves, which are of the type used in both short wave and longer wave radio transmission.

All these radiations travel with the same velocity as that of visible light and differ only in wave-length or frequency. Now radio waves are produced by generating devices in which electrical charges vibrate in a somewhat similar manner to the vibrations of a piano string. The oscillation of these electrical charges causes a so-called electromagnetic wave to be transmitted through space at the same frequency as the oscillating electric charges. If we are to account in a similar manner for the very much shorter wave-lengths sent out by atoms and which we receive as visible light, we must assume that the atoms also contain electric charges, vibrating at frequencies which correspond to those of all the frequencies in the whole spectrum. Such electric charges are obviously supplied by the electrons present in the atomic structure, and from this argument we reach the conclusion that the light originating from any atom is due to vibrations of electrons within the atom.

However, this view regarding the origin of spectral lines met with insuperable difficulties and it remained for Neils Bohr, a young Danish physicist, to suggest, in 1913, a theory which has profoundly affected the whole subsequent development of both physics and chemistry.

Bohr's theory may possibly be understood best by describing briefly an experiment which was carried out in 1914 by 2 German physicists, Franck and Hertz. They used a 2-electrode tube similar in principle to those used in radio sets, but containing mercury vapor. By applying a voltage between the electrodes any desired energy could be imparted to the electrons emitted by the cathode. A spectroscope pointed at the tube showed that when the energy of the electrons reached a certain critical value, and not until then, a single ultra-violet line appeared. As the voltage was increased still further, other lines were observed until finally all the lines in the mercury spectrum appeared.

The interpretation of this experiment on the basis of the Bohr theory is that at the first critical voltage, the electron has just sufficient energy to excite a mercury atom with which it collides. The mercury atom in the excited state is in somewhat the same condition as a stone lifted to a slippery platform at some height above the ground. The stone ultimately slides off the platform and in falling to the ground gives up exactly the same amount of energy as was used in lifting it. The excited atom also tends to return to its normal state and in this process it emits a radiation having a frequency proportional to the difference in energy between the excited and normal state.

In these excited states the electrons in the atomic structure revolve in orbits which are further removed from the center, or nucleus, than in the case of the unexcited atom. And the emission of a spectral line or radiation of definite frequency is due therefore not to the revolution of the electron in its orbit, but to

a transition of the electron from one excited state to a state of lower excitation energy.

On the basis of this theory, we can venture to predict the conditions under which it should be possible to obtain a high efficiency of light from any source. As an illustration let us consider the process of light production in sodium vapor. The most intense line in the spectrum of this atom is due to a transition from the first excited state to the normal state. In order to produce this excited state, the electrons must acquire an energy corresponding to about 2 volts. Therefore, we must try to arrange conditions in a discharge tube so that all the electrons from the cathode receive about this amount of energy.

Similarly in the case of other spectra, the aim of the experimenter must be to design the tube and determine the proper conditions of pressure so that the electrons make the maximum number of efficient collisions.

Naturally the practical problem of producing visible light at high efficiency has received a great deal of attention. It is customary to express light efficiency in terms of so many lumens of light flux per watt of electrical power. For instance, the ordinary 60-watt tungsten lamp operates at an efficiency of about 12 lpw.

The lumen is a measure of the brightness of any source in terms of the human eye as a detector of light. Now ordinary observation shows that the eye is not equally sensitive to all parts of the spectrum. We cannot see either ultra-violet or infra-red rays. In fact, the sensitivity is zero at each end of the visible spectrum, increases toward the center and reaches a maximum for greenish yellow light which has a wave-length of about 1/70,000 in. A source emitting light of this color only, without any accompanying infra-red or ultra-violet, would be the most efficient source attainable—the ideal cold light, and would emit 621 lumens per watt. For every color there exists a certain ideal efficiency which depends upon the sensitivity of the eye for the particular color, and for white light this maximum theoretical efficiency is about 225 lumens per watt.

As the temperature of any incandescent solid is increased, the efficiency of light production increases. The increase in efficiency of gas filled tungstem lamps over the vacuum type lamp is due to the higher temperature of operation of the filament. However, as a converter of electrical energy into light, even the gas filled lamp is only about 5 to 6 per cent efficient.

In the case of electric arcs in low pressure mercury vapor and neon gas, the efficiency obtained is about 15 lumens per watt, while an arc in sodium vapor yields 50 to 60 lumens per watt, which represents an energy conversion of about 12 per cent.

It is thus evident that we are still quite a distance from a theoretically ideal efficiency in the conversion of electrical energy into light. The difficulties to be overcome in striving for this objective would appear to be both numerous and great. But at least we know the nature of the problems, and future investigation as well as resourceful ingenuity will undoubtedly bring about further developments in this field, which will be of great theoretical and practical importance.

A Chart for Estimating Cost of Units of Plant

Herewith is presented a chart by means of which the in-place cost of units of plant of pole-using utilities can be estimated; the principle upon which the chart is based may be applied also to many other classes of plant and equipment. A typical example illustrating the use of the chart is given.

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ASSOCIATE A.I.E.E.

ALTHOUGH designed principally for estimating the in-place value of units of plant of pole-using utilities, the chart described in this article is readily adaptable to estimating similar values of wire and other units. The particular chart shown was designed so as to be applicable to several kinds of poles in widely differing localities; therefore, it allows for an extended range of numerical quantities. For a utility using only a single kind of pole in a restricted locality representing a limited range in numerical quantities such as weight, freight rate, and work unit, the chart could be simplified greatly. For example, if only one labor rate and one freight rate were applicable each of the 2 upper rectangles might be reduced to straight lines dropping from single logarithmic scales.

Elements expressly included in the in-place cost when derived from the chart are: the cost of freight and labor; material and supply expense; and the cost of distribution. Provision is made for company haul and work train distribution including labor of spotting and unloading from flat cars as well as rental for the train (see Table I).

From this chart also can be read separately the cost of freight, and the cost of labor, as well as the total in-place cost, or any combination of these elements. The fundamental data provided for, aside from the work train distribution, are represented by 5 primary scales as may be seen from the chart itself.

Operations performed graphically upon the chart are 2 multiplications and 2 additions. The large square in the upper right hand corner and the similar rectangle on the opposite side of the chart are the parts on which the multiplications are performed. The large central rectangle on which the curves are

Prepared especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

superimposed is the part upon which the additions are performed.

The general method of procedure may be described as one in which 2 multiplications are performed graphically on the 2 upper rectangles and added together on the lower, central rectangle to which sum then is added graphically the material and supply expense as a second operation on this rectangle. The final graphical value is read from the long scale running diagonally across the large, lower rectangle unless it is desired to obtain for poles the value of the pole exclusive of setting. If so the final graphical value is read from the heavy black scale on the right captioned "cost of labor plus cost of freight" (disregarding the significance of the caption). In determining values by the use of the chart, operations can be expedited by disregarding actual recognition of quantities representing intermediate values. Lines to be followed in arriving at final values may be traced throughout without regard to intermediate scales.

For poles involving expense of distribution by work train along a railroad right-of-way Table I is provided. In such instances before starting the graphical operations, to facilitate the use of the chart, the appropriate hours of labor for work train distribution shown in the table should be added mentally to the hours of setting. Figures shown in Table I for work train distribution and rental are ficticious; in using the chart appropriate local quantities should be determined. If any allowance for company haul is to be made in terms of dollars per hundred pounds it may be added similarly to the freight rate before beginning.

Detailed instructions for using the chart are given on the page on which the chart itself appears. Dotted lines have been drawn on the chart to facilitate interpretation of the descriptive matter. In the sample problem thus traced the following quantities have been assumed:

Height of pole	25 ft
Weight of pole	350 lb
Freight rate	$0.415 per 100 lb
Labor of setting	4.72 hr
Labor rate	$0.47 per hr
Material plus supply expense	$2.38

Any allowance for company haul in terms of dollars per 100 pounds should be added at the outset to the freight rate of $0.415. In this problem no company haul was assumed; hence by dropping from the intersection indicated in the upper right hand rectangle the cost of freight may be read as $1.45.

In Table I the labor of distribution for a 25-ft pole is shown as 0.32 hr. This added to the 4.72 hr of setting labor gives for the total amount of labor 5.04 hr. By dropping from the intersection of the coordinates of this value and that of the 47-cent labor rate on the upper left hand rectangle the cost of labor may be read as $2.37.

On the large, lower rectangle from the intersection of the coordinate for cost of freight and the coordinate for cost of labor, the value of the sum ordinarily would be read directly from the point of intersection as described later in the discussion of interpolation. However, to simplify this explanation, follow the curve indicated by the dotted line to the scale "cost of labor plus cost of freight" where the value of the sum may be read as $3.82.

Similarly, with this as a new coordinate and the coordinate for the material plus supply expense ($2.38), trace from their intersection, as indicated, to the diagonal line and read the value of $6.20. To this now add the amount for train rental (30 cents) shown in Table I. This gives $6.50 which is the total in-place value of the 25-ft pole under the conditions assumed.

If care is exercised in interpolating values on the chart the accuracy of reading is comparable to that of a slide rule. Interpolation by following curved paths, however, is recognized as impracticable; it is merely illustrative of the principle of operation, and in actual practice it generally will be dispensed with. Interpolation may be facilitated greatly by using the gridwork of straight lines as a reference. It may be observed that a point of intersection of 2 straight lines is the same relative number of divisions from each adjacent curve when measured along either of the straight lines or when measured along a normal to the curves.

Table I—Typical Work Train Distribution Per Pole*

Length of Pole, Ft	Labor, Hr	Train Rental
15	0.21	$0.20
20	0.27	.25
22	0.28	.27
25	0.32	.30
30	0.36	.35
35	0.45	.40
40	0.54	.45
45	0.62	.50
50	0.70	.55
55	0.91	.60
60	1.09	.65
65	1.38	.70
70	1.50	.80
75	1.80	.85
80	2.25	.90
85	2.60	.95

* Local charges should be determined; these figures are given only to indicate the information needed.

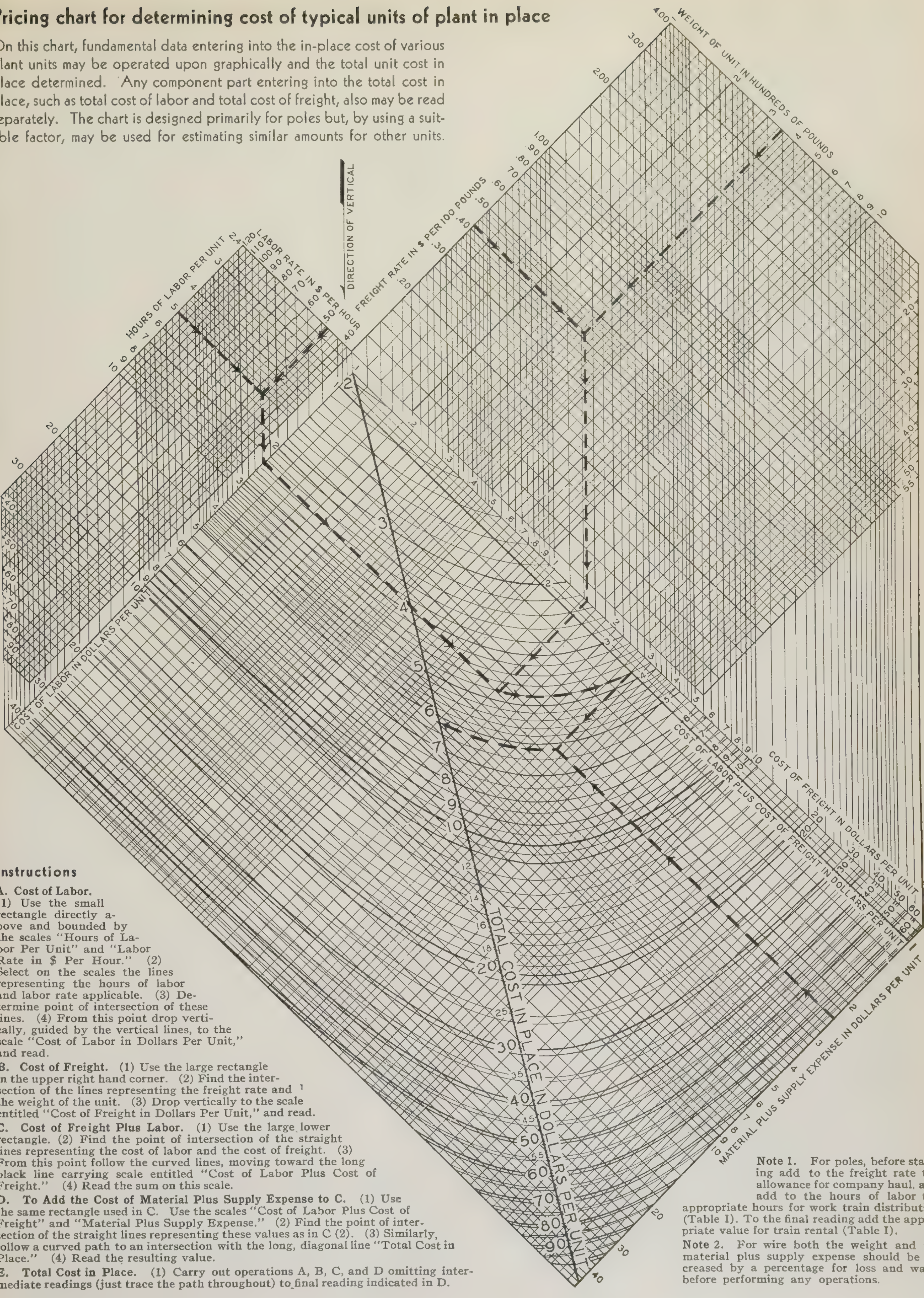
Thus, interpolations can be made by reading along the straight lines the proportionate distance between curves; inaccuracies arising out of curve tracing then will be eliminated.

Greatest application of the chart will be found in estimating values of units for which the cost of labor and the cost of freight are each less than $10; the greatest degree of accuracy of reading will be within these limits. The number of poles for which values would lie outside of these limits would introduce only a small error in making estimates for the average pole line.

The chart also affords quick and ready determination of values when a calculating machine is either an inconvenience or is at the time inaccessible. The speed with which operations can be performed when in the hands of one familiar with its operation should prove an economy in making valuations of existing plant. It may be used also as a ready check upon computations of others.

Pricing chart for determining cost of typical units of plant in place

On this chart, fundamental data entering into the in-place cost of various plant units may be operated upon graphically and the total unit cost in place determined. Any component part entering into the total cost in place, such as total cost of labor and total cost of freight, also may be read separately. The chart is designed primarily for poles but, by using a suitable factor, may be used for estimating similar amounts for other units.



Instructions

A. Cost of Labor. (1) Use the small rectangle directly above and bounded by the scales "Hours of Labor Per Unit" and "Labor Rate in $ Per Hour." (2) Select on the scales the lines representing the hours of labor and labor rate applicable. (3) Determine point of intersection of these lines. (4) From this point drop vertically, guided by the vertical lines, to the scale "Cost of Labor in Dollars Per Unit," and read.

B. Cost of Freight. (1) Use the large rectangle in the upper right hand corner. (2) Find the intersection of the lines representing the freight rate and the weight of the unit. (3) Drop vertically to the scale entitled "Cost of Freight in Dollars Per Unit," and read.

C. Cost of Freight Plus Labor. (1) Use the large lower rectangle. (2) Find the point of intersection of the straight lines representing the cost of labor and the cost of freight. (3) From this point follow the curved lines, moving toward the long black line carrying scale entitled "Cost of Labor Plus Cost of Freight." (4) Read the sum on this scale.

D. To Add the Cost of Material Plus Supply Expense to C. (1) Use the same rectangle used in C. Use the scales "Cost of Labor Plus Cost of Freight" and "Material Plus Supply Expense." (2) Find the point of intersection of the straight lines representing these values as in C (2). (3) Similarly, follow a curved path to an intersection with the long, diagonal line "Total Cost in Place." (4) Read the resulting value.

E. Total Cost in Place. (1) Carry out operations A, B, C, and D omitting intermediate readings (just trace the path throughout) to final reading indicated in D.

Note 1. For poles, before starting add to the freight rate the allowance for company haul, and add to the hours of labor the appropriate hours for work train distribution (Table I). To the final reading add the appropriate value for train rental (Table I).

Note 2. For wire both the weight and the material plus supply expense should be increased by a percentage for loss and waste before performing any operations.

Corona Loss at 220-330 Kv

Results of previous corona loss measurements are corroborated and new information revealed in recent tests made at the Ryan laboratory, Stanford University, Calif. The experiments included tests on conductors as large as 2 in. in diameter, at line potentials as high as 600 kv, and an investigation of the effects of several different surface treatments.

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CORONA loss measurements made during the summer and fall of 1931 at the Ryan laboratory, Stanford University, Calif., extended the range of corona loss data to conductor sizes beyond those investigated during 1930, the results of which were presented in a paper "Corona Loss Measurements on a 220-Kv 60-Cycle 3-Phase Experimental Line," by Carroll, Brown, and Dinapoli[1] (see references at end of article). This investigation was made possible by the Department of Water and Power, City of Los Angeles; the results are being used in the economic study of the transmission of Boulder Canyon power to Los Angeles. Losses were measured on a 3-phase line 700 ft long using 3 conductor specimens: a 1.125-in. hollow copper cable, a 1.49-in. hollow copper cable, and a 2-in. hollow aluminum cable. Voltages as high as 600 kv between conductors were used.

Results of the investigation may be summarized as follows:

1. Further evidence proves that die grease and other foreign matter, existing on cables as received from the manufacturers, greatly increases the corona loss, and that this loss can be eliminated partially by washing the cable with a solvent, soap solution and thoroughly rinsing in water.

2. Cleaning the cable surface by scratch brushing lowers the corona loss only slightly below that of a new cable properly washed.

3. Polishing the cable surface by buffing temporarily decreases the loss on the cable below that of a new cable properly washed.

4. Dragging a clean cable a distance of $^1/_2$ mile increases the loss on the cable above that of a washed cable, but the loss is less for this treatment than for the new, unwashed cable as received from the factory.

5. The surface of clean washed cables that subsequently have been dragged, ages rapidly; so that with a year of weathering the loss is practically the same as for a new, washed, undamaged cable.

6. The surface produced by buffing ages rapidly, and, as observed over one week's time, showed a great variation in loss which was not regular but at times approached the loss for new, washed cable.

7. Variation in corona loss of new, washed cables shows that the voltage shift for the same power loss on cables of different sizes is practically proportional to $r \log S/r$, which is the factor in E_0 which is varied by dimensions.

8. Insulator loss, if not considered, may introduce an appreciable error in corona loss measurements at high voltages. The loss can be eliminated partially by properly shielding the insulator strings.

9. A completely transposed line 1,050 ft long showed the same corona loss as the same length of line untransposed. A horizontally spaced line showed a slightly higher loss than the same length of line with equivalent triangular spacing.

A more detailed discussion of the results is given later in the article.

General Layout and Test Method

All cables tested were new unused cables on the original reels which came from the factory. Details of these cables are as follows:

1. The 1.125-in. cable was hollow copper of I-beam construction. This was a single-layer cable with 24 strands in the one layer. The diameter of the strands was 0.125 in., while the diameter of the supporting twisted I-beam core was 0.875 in.

2. The 1.49-in. cable was a double-layer hollow-core copper cable of I-beam construction. The diameter of the strands in both layers was 0.0971 in., while the diameter of the supporting twisted I-beam core was 1.100 in. The inner layer contained 37 strands; the outer, 43 strands.

3. The 2.0-in. hollow aluminum cable was a single-layer cable, with the strands supported by a flexible-tube center. The outside diameter of this flexible tube was 1.636 in. The outside layer of the cable was of 30 strands of aluminum with a strand diameter of 0.182 in.

4. The No. 2 B&S gage wire used in the transposition tests was hard drawn solid copper.

For comparing losses of the different conductors, all specimens were mounted in a horizontal configuration with a clearance to ground of 30 ft and a sag of 16 ft. The spacing was such that the ratio of S/r (r is the radius of the conductor; S, the conductor spacing) was practically the same for all tests except that of the 2.0-in. conductor; for good clearance the physical dimensions limited the spacing of that conductor to 30 ft. For the method of supporting conductors, see the paper referred to in the first paragraph of this article.

Some variations of corona loss due to the surface condition of the conductor had been found by previous test, but it was desired to carry on such tests over a wider range of conditions, such as: scratch brushing and polishing the conductor, which gave an ideal surface; and dragging the conductor, which left it more nearly the same as found in actual practice. Since so much depends on the surface condition of the conductor, considerable care was exercised in handling the specimens.

Insulator strings used on the 1.125-in. cable consisted of 18 10-in. units, shielded at the lower end with a Koontz type shield. This shield is a cast-iron plate approximately $^3/_8$ in. thick with a 1-in. bead around the edge. It is elliptical in shape, the larger diameter being 20 in. and the smaller one 12 in.

Essentially full text of "Corona Loss Measurements for the Design of Transmission Lines to Operate at Voltages Between 220 Kv and 330 Kv" (No. 32-113) presented at the A.I.E.E. Pacific Coast convention, Vancouver, B. C., Aug. 30–Sept. 2, 1932.

The shield is attached to the line clamp so that the distance between the line insulator and shield is about 1 in. The long axis of the shield is parallel to the conductor, the extreme ends being turned up 3 in. to form arcing tips.

Insulator strings for the 1.49-in. and the 2.0-in. cable were similar, but were shielded on each end by an aluminum ring radio shield. These rings were toroidal in shape, the diameter of the tube of which the rings were made being 2.5 in. and the large diameter of the rings, 22 in.

Voltage was applied to the line by means of 3 350-kv 350-kva transformers Y-connected on the high voltage side, and Δ-connected on the low voltage; these transformers were energized from a 2,300-volt sine-wave alternator.

Fundamentally, there was no difference in the method of making these measurements from that used in tests reported in the former paper.[1] Briefly, this method involved the use of 3 single-phase high-voltage wattmeters, each connected directly between one line and ground. Dynamometer type meters were used. The line was fed directly through the current coil of the meter, while the potential coil was connected directly between line and ground by means of a high-voltage water-resistor multiplier.

Certain modifications in the former measuring equipment were necessary for satisfactory tests on the larger conductors. One change was the mounting of the test specimen nearer the laboratory, thereby reducing the length of the shielded wattmeter lead from 450 to 100 ft. This reduced to a negligible value the error caused by the capacitance

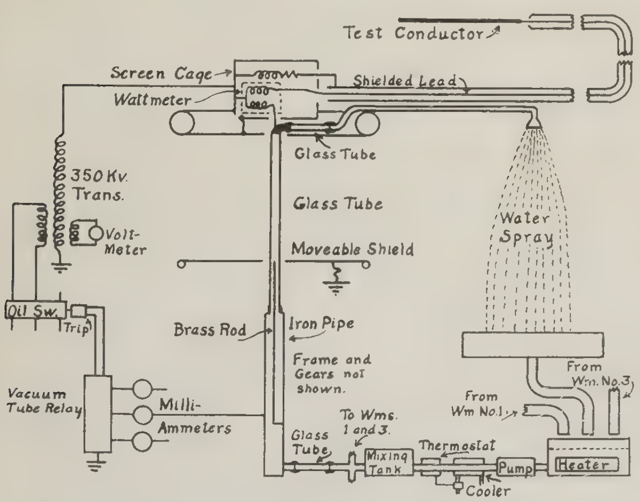

Fig. 1. Wattmeter connections

between the lead and shield shunting the field coil of the wattmeter, up to the highest voltage used.

Wattmeter Multiplier

The high voltage wattmeter multiplier consisted of a glass tube 0.4-in. inside diameter and $^{1}/_{16}$-in. glass, mounted between 2 circular iron-mesh shields 4 ft in diameter. The lower shield was mounted on a movable framework actuated by screws; the upper shield was supported by oven-dried paraffin-treated redwood sticks $1^{1}/_{2}$ in. in diameter. This support was better than bakelite or similar insulation, because of its lower dielectric constant.

Mounted on the edge of the upper shield was a torus 6 in. in diameter which showed no signs of corona at 350 kv. Inside the glass tube was arranged a brass rod $^{1}/_{8}$ in. in diameter. This rod was mounted in a water-tight cylinder below the lower shield in such a manner that it moved upward by means of a screw arrangement at the same rate as the lower shield. With such an arrangement, the shield and the brass rod moving together, the resistance of the multiplier could be changed uniformly and would have correct shielding at all times. A schematic diagram of the equipment is given in Fig. 1.

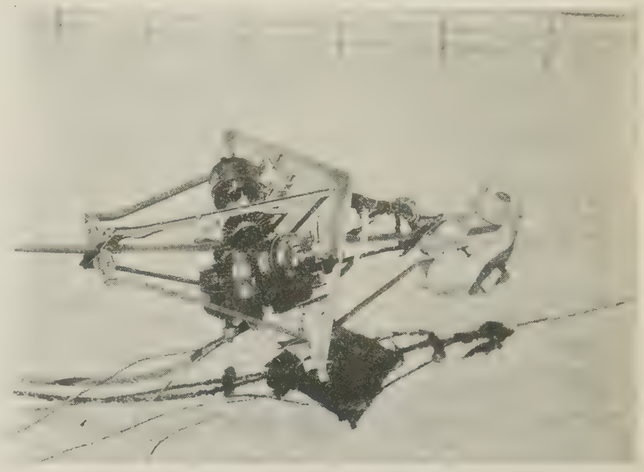

Fig. 2. Assembly of cable buffing motors

Distilled water was circulated through the glass tubes of the 3 multipliers by means of a pump, the water being discharged at the high voltage end through a spray similar to the method used in previous measurements. By the use of the distilled water a multiplier of minimum length could be made, reducing to a minimum the capacitance of the resistor to the shields and to ground. At 350 kv and with a current of 50 ma, 17.5 kw of energy is absorbed by the resistor. To prevent excessive rise in temperature the water flows through each resistor at the rate of 5 gal per min. This gives a temperature rise of 13 deg C up the water column. To reduce the error caused by the change in resistance of the water due to increase in temperature, water entering the resistor was maintained at 40 deg C by thermostatic control. At this temperature energy dissipated due to evaporation in the spray is approximately 5 kw so that at low voltages the energy absorbed by the multiplier was less than that dissipated in the spray. In order to maintain this 40 deg C temperature it was necessary to heat the water before it entered the multiplier. At the higher voltages energy absorbed by the multiplier was greater than that dissipated by the spray; under these conditions it was necessary to cool the water. This was done by means of a water cooling coil.

As the water is circulated through the system it

picks up certain impurities and in time the resistance lowers sufficiently to necessitate some adjustment. This adjustment was accomplished by passing the water between plates of aluminum and carbon with a d-c potential of 125 volts between the plates, the aluminum being positive; the resistance of the water was found to increase considerably, in some cases as much as 5 times its original value.

The wattmeter instruments were protected electrically by low voltage safety gaps across their coils and also by a special vacuum tube relay in the ground end of the multiplier.

Measurements

At the beginning of the tests the aim of the engineers on the project to which the results were to be applied, was to keep the corona loss a minimum within reasonable limits of conductor cost. For test purposes, a loss of $^1/_2$ kw per mile was suggested. At 275 kv this means a power factor of the test specimen of 0.1 per cent. Such a condition is extremely exacting in measurements at such high voltages. It was necessary to check carefully all possible sources of error in the measuring equipment, and approximate their magnitudes. Such sources included the shielding of the water resistor multiplier, the capacitance between the wattmeter lead and its shield, the wattmeter itself, and the measurement of the voltage. All meters were carefully calibrated, and as no standards were conveniently available for use at extremely low power factors, a further check by an absolute method was devised.

Line voltages were measured from the voltmeter coil of one of the transformers. These measurements were corrected by calibration curves obtained with a 50-cm sphere gap. A power circuit, harmonic analyzer measurement of the voltmeter coil voltage and also of the current through the high voltage wattmeter multiplier showed the voltage wave to be practically sinusoidal.

Air temperature and humidity measurements were similar to those of previous tests, thermometers being placed in the shade out-of-doors and in the direct air stream from a small fan. However, one addition was made to this equipment, namely, a short specimen of cable with a thermometer mounted inside in such a manner that it could be removed and the temperature read; this cable was always mounted in the sun about 6 ft above the ground. The temperature as recorded here was assumed to be the same as that of the test specimen.

Discussion of Results

During the course of the tests variations in loss were observed during the day that are far in excess of what could be acounted for by variations in δ, the air density factor. Further, data now being collected, yet not sufficiently studied to be presented at this time, indicate that the value of δ should be calculated from the conductor temperature rather than from the air temperature; and that the variation of E_0 with δ is not a direct proportion as previously assumed, but is some other function of the air density factor.

As the volume of data available on corona loss is increased, the difficulty of obtaining a formula to fit all of the curves for the conditions involved is more evident. Any one calculating corona loss on lines realizes that the economic range for operating lines is with the conductors of a diameter such that the corona loss is less than 10 kw per mile; in many cases the economic conductor size is such as to give a corona loss of less than 1 kw per mile. Since these low values of loss are the most needed and since it is in this range that present formulas[2,3] and test results

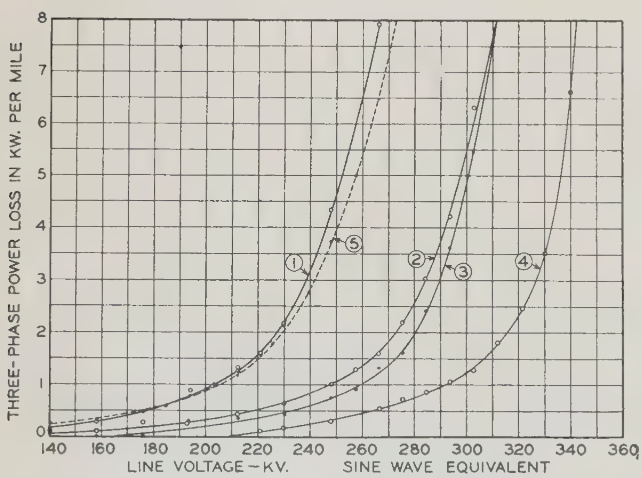

Fig. 3. (Left) Corona loss curves showing effect of cable surface; 1.125-in. cable, 22-ft horizontal spacing

Curve No.	Barom. In. Hg	Temperature, Deg F Dry Bulb	Wet Bulb	Cable	Date	Surface Condition
1	29.79	77	66	...	8/28/31	New
2	29.84	77	65	...	9/ 3/31	Washed
3	29.92	69	59	71	9/28/31	Scratch brushed
4	29.84	72	55	80	10/ 3/31	Buffed
5	29.78	64.5	57	66	10/13/31	Dragged

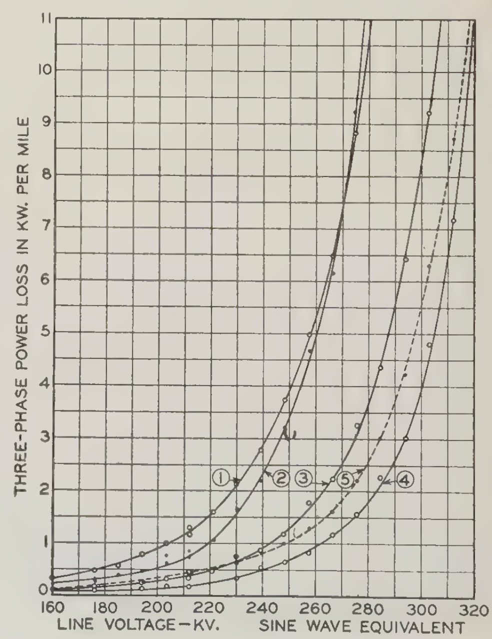

Fig. 4. (Right) Corona loss curves showing aging of dragged cable; 1.125-in. cable, 22-ft horizontal spacing

Curve No.	Barom. In. Hg	Temperature, Deg F Dry Bulb	Wet Bulb	Cable	Date	Surface Condition
1	29.78	64.5	57	66	10/13/31	Dragged
2	29.87	68	58	78	10/14/31	Dragged
3	30.14	60	56	78	12/ 4/31	Dragged
4	30.17	60	50	68	1/ 6/32	Dragged
5	29.84	77	65	....	9/ 3/31	Washed

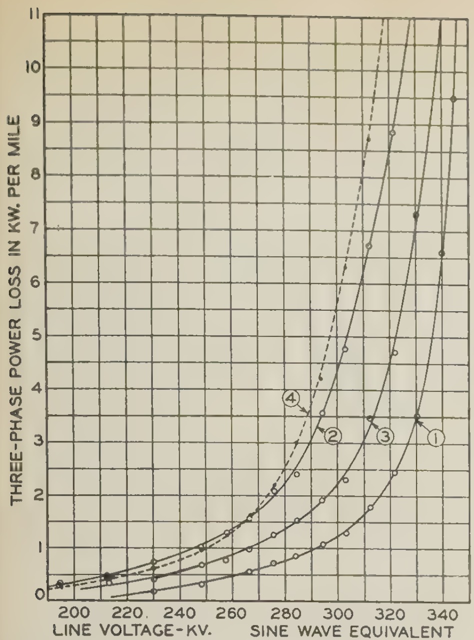

Fig. 5. (Left) Corona loss curves showing aging of buffed cable; 1.125-in. cable, 22-ft horizontal spacing

Curve No.	Barom. In. Hg	Temperature, Deg F Dry Bulb	Wet Bulb	Cable	Date	Surface Condition
1	29.84	72	55	80	10/ 3/31	Buffed
2	29.95	68	58.5	80	10/ 5/31	Buffed
3	30.05	69	59	79	10/12/31	Buffed
4	29.84	77	65	....	9/ 3/31	Washed

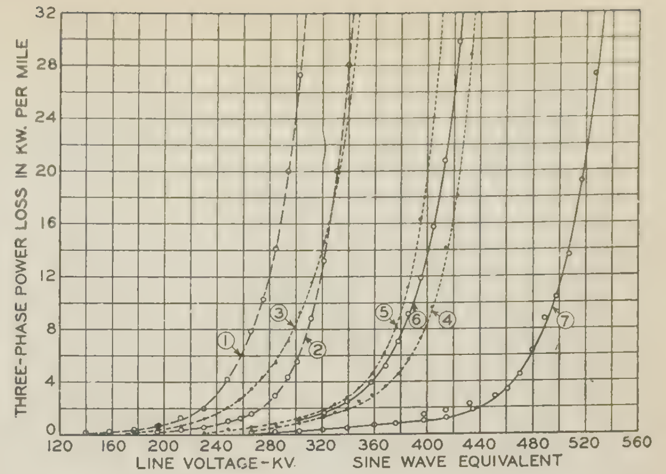

Fig. 6. (Right) Corona loss curves showing variation of loss with cable diameter

Curve No.	Cable Diam in In.	Barom. In. Hg	Temp., Deg F Dry Bulb	Wet Bulb	Cable	Date	Horiz. Spacing in Ft	Surface Condition
1	1.25	29.79	77	66	...	8/28/31	22	New
2	1.125	29.84	77	65	...	9/ 3/31	22	Washed
3	1.49	30.01	68	58	76	10/23/31	30	New
4	1.49	30.05	71	53	80	10/27/31	30	Washed
5	1.49	29.85	80	59	82	10/29/31	22	Washed
6	2.0	29.93	82	61	93	11/ 6/31	30	New
7	2.0	30.05	66	48	80	11/12/31	30	Washed

show the greatest deviation, the data given in this article are presented as recorded with voltage and meter corrections only; no correction for air density has been made.

Study of Surface Conditions. As had been found in previous measurements at the Ryan laboratory,[1,4] die grease or other foreign matter on the cable as it is received from the manufacturers causes a material increase in the corona loss. New cables, washed with gasoline and further washed with a soap solution and thoroughly rinsed with water showed a substantial decrease in loss from that of new cable unwashed. All cables tested were treated in this manner: tested as received from the factory or as nearly so as possible, then thoroughly washed and again tested. In addition to these 2 surface conditions, the 1.125-in. cable was tested after 3 other surface treatments, namely, scratch brushed, buffed, and dragged.

Curves for the various surface conditions of the 1.125-in. cable are given in Fig. 3. Curve 1 is the loss for the cable when it was first erected. This cable had been stored at the laboratory for 3 years. Curve 2 gives the loss as obtained after the washing treatment. The explanation of the physical change resulting in the very unusual electrical change cannot be given. It has been found to exist wherever new cables have been tested and then washed, and is further evidenced by the excessive noise on new lines that gradually decreases with aging of the lines. Curve 3 was obtained on the 1.125-in. cable after it had been completely polished with steel, scratch brushed. This polishing was done by mounting the brushes on $^1/_2$-hp motors which were carried along on the conductor by a frame supported on rubber-tired casters. See Fig. 2. This treatment produced a satin finish, removing all oxides and giving an absolutely clean cable. This surface appeared, when examined under a magnifier, as though it had been hammered with extremely minute hammers. These minute depressions were uniform over the complete cable and were not nearly so deep as the die marks found on many acceptable cables. This treatment, as seen from the curve, produced a slight decrease in the corona loss. Curve 4 was obtained on the 1.125-in. cable after it had been buffed with cotton buffing wheels and nickel rouge as an abrasive. This treatment produced an extremely high polish on the cable so that it could be classed as having a roughness factor of unity other than that imposed by the stranding. As can be seen from the curves, this buffed cable had an extremely low loss. Unfortunately, however, this was not a permanent condition as will be discussed later.

To simulate more nearly the conditions found in field erection, the cable was dragged for $^1/_2$ mile in the fine crushed rock on a road shoulder. This produced a decided roughening of the surface and carried with it considerable dirt from the road. The loss for a cable as erected after this treatment is shown by curve 5. It was rather surprising to see that this curve fell below the loss curve for the same cable as received from the factory. However, it should be remembered that the grease, die compound, and other foreign matter had been completely removed from the conductor before it was dragged; thus this condition may be better than that of a new cable that had been dragged in erection. This rough surface also aged rapidly as discussed in the following paragraph.

Aging of Surfaces. In order to have some definite information as to the aging of dragged cables, the 1.125-in. cable was allowed to remain in place for 7 months. During this time appreciable aging occurred as may be seen in Fig. 4. Aging was uni-

formly progressive as shown by curves 1, 2, 3, and 4, the loss decreasing with time. Curve 1 was taken immediately after the cable was dragged; curve 4 shows that the loss had decreased until it was less than that for the washed cable, curve 5. A further test taken at the end of the 7 months showed that the loss was practically unchanged. This decrease of corona loss due to aging of the conductor is extremely gratifying and helpful as it obviates the need for purchasing excess copper or for expensive erecting precautions to eliminate the loss resulting from slight roughening.

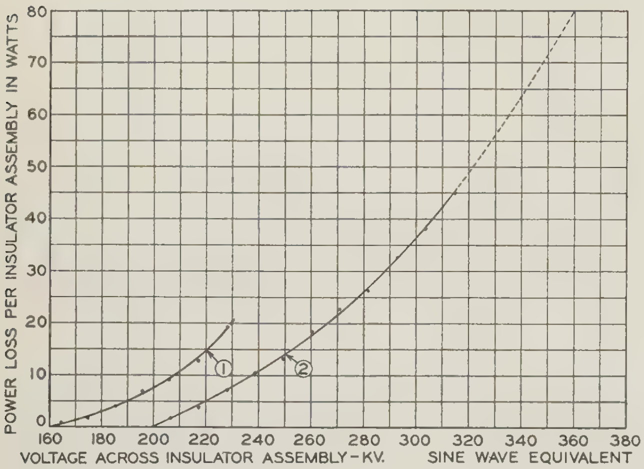

Fig. 7. Losses on insulator strings

Curve 1. 18 10-in. units, 5-in. hanging length; Koontz shield on lower end of string only
Curve 2. 18 10-in. units, 5-in. hanging length; aluminum radio shields at each end of string

Aging of the buffed cable was not so uniform in progression as that of the dragged cable. By reference to Fig. 6 it can be seen that the lowest loss on the buffed cable is that of curve 1, obtained on the day the buffing was completed. Two days later the loss was much higher, as shown by curve 2. This curve approaches that of the washed cable, as given by curve 4. Nine days after the buffing as shown by curve 3, the loss had decreased to a lower value again, but not so low as that obtained immediately after buffing. The only explanation that can be given for this irregular behavior of the buffed cable is that the surface was more perfect than could be obtained in open air.

From observations of the various conditions as they effect corona loss, it can be said that the reliable surface to use for comparing cables is that of a relatively new, unused cable which has been thoroughly cleaned with gasoline or some solvent for cutting the die lubricant, followed by a soap and water cleaning. Some other cleaning methods may give lower corona loss, but all cables to be compared should be cleaned in the same manner. For this reason the comparison of the different sizes is made on the basis of tests on washed cable.

Comparison of Size of Cable. The curves of Fig. 6 show the losses obtained on 1.125-in., 1.49-in., and 2.0-in. cables. It can be seen from curves 2, 4, 5, and 7, for washed cables, that the voltage shift for the same power loss is practically proportional to the part of E_0 which is affected by dimensions, namely, $r \log S/r$, where E_0 is the disruptive voltage, r the radius of the conductor, and S the spacing. Washing the 1.125-in. cable shifted the loss so as to allow it to operate with the same loss, 40 kv higher than the new unwashed cable; corresponding values for 1.49-in. and 2.0-in. cable are 100 and 110 kv, respectively.

Tests on new unwashed cable, curves 1, 3, and 6, show the 1.125-in. cable to be better in proportion than the other unwashed cables. This is due partially to the fact that the 1.49-in. cable was rained on slightly before the first loss measurement was obtained. This is known to raise the loss of a new cable the first time it occurs. Further, the 1.125-in. cable had aged in storage for 3 years before erection, which could have lowered its loss.

Insulator Loss Data. Curve 1 of Fig. 7 gives the loss on one of the insulator and shield assemblies used to support the 1.125-in. conductor. Since the loss was practically 0 up to 160 kv to neutral, no correction for insulator loss was necessary.

Curve 2 shows the loss for the insulator assembly used on the 1.49-in. and the 2.0-in. cables. From this curve it can be seen that the insulator loss is practically 0 for voltages to neutral of 200 kv (346 kv line). Thus this insulator string showed practically no corona loss over the voltage range where the 1.49-in. cable was tested. However, the low loss range of the 2.0-in. cable covers practically the same range as the loss curve for the insulator string. This correction was applied to all of the data on the 2.0-in. cable equal to the loss on the proper number of insulator assemblies involved.

Configuration of Line. It was desired to determine

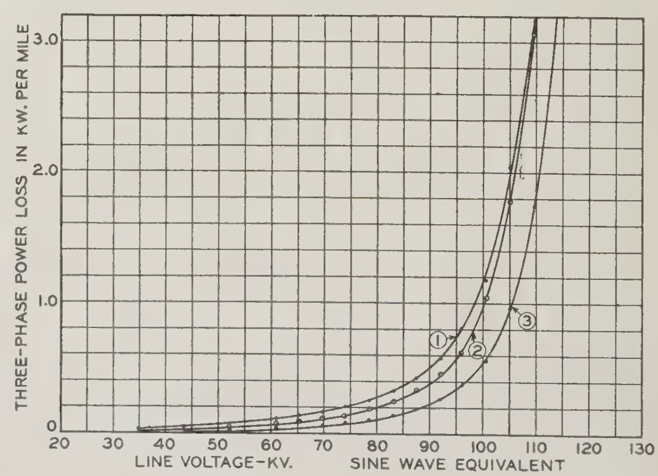

Fig. 8. Corona loss curves showing effect of configuration and transposition; No. 2 wire, used cable, weathered surface

Curve No.	Barom. In. Hg	Temperature, Deg F Dry Bulb	Wet Bulb	Cable	Date	Spacing in Ft	Configuration
1	30.07	52	46	55	12/ 1/31	5.05	Flat
2	30.07	53.5	47	57	12/ 1/31	5.05	Flat Transposed
3	29.92	54	45.5	60	11/27/31	6.3	Triangular

whether there was a change in the loss on lines due to the configuration. A 3-phase line of No. 2 B&S gage wire was erected with a total length of 1,050 ft. The loss was measured on this line for a horizontal spacing of 5.05 ft and an equivalent triangular spacing of 6.4 ft.

Comparing curves 1 and 3 of Fig. 8 shows that the loss was slightly less for the triangular, than for the flat configuration. This difference is slightly greater than could be attributed to daily variation changes or any change in the surface of the wire due to handling, and appears to be a valid decrease in the loss.

A further attempt to determine the effect of transposing was studied. The line was broken into 3 equal sections so that there was a complete barrel or a complete transposition section. The loss as determined on this transposed line is given by curve 2, and is practically the same as that for the untransposed line, curve 1. The very slight difference in the curves could be accounted for by the daily variation as observed on other cables.

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Vertically Cut Sound Records

Limitations of laterally cut sound records have led to renewed researches in the recording and reproducing of sound with particular attention to the inherently better, but more difficultly achieved vertically cut record. The aggregate result of these researches represents a distinct forward step in the art.

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VERTICAL SOUND RECORDING, that is recording in which the record of the sound waves is cut as a vertically undulating groove in the surface of the recording medium, is an advance in this art made possible only by continued and persistent research. It has been known for many years to be superior in certain respects to lateral sound recording, that is, recording in which the record of the sound waves is recorded as a laterally undulating groove in the surface of the recording medium. However because of limitations in the recording and reproducing equipment most of the sound records in the past, of which the ordinary disk phonograph record is perhaps the best example, have been of the laterally cut type. The fundamental difference between the 2 types of records may be observed in Figs. 1 and 2.

Limitations of the laterally cut records have led to continued development of recording and reproducing equipment, until equipment satisfactory for vertically cut records now has been obtained. At the same time, research in the processing and manufacture of the records themselves had led to further improvements. The aggregate result of these researches is such that:

1. Noise has been reduced 25 to 30 db.
2. Volume range has been increased from about 25 or 30 db to about 50 or 60 db.
3. Frequency range has been extended to about 9,000 cycles.
4. Playing time for a 12-in. record may be increased from about 4 min to at least 15 min.
5. Record life has been increased tremendously.
6. More faithful reproduction has been achieved as a result of better frequency characteristics and less distortion.

In viewing recent advances it is of interest to review briefly the history of the mechanical recording of sound.

History of Sound Recording

The phonograph and the telephone were invented at nearly the same time and have grown side by side. Knowledge gained in studies of the telephone has aided the phonograph, and much of the advance in phonograph art has been contributed by men primarily associated with the telephone. Recording of sound may be traced back many years. In 1807 Thomas Young described a method of recording the vibrations of a tuning fork on the surface of a drum. The method as described was reduced to practice by Wertheim in 1842. Leon Scott, in 1847, invented the phonautograph, an instrument for the recording of sound which was further improved by König and Barlow, and in 1874, Alexander Graham Bell applied the drum and the bones of the human ear to obtain tracings on smoked glass.

Based upon "Vertically Cut Sound Records" (No. 32-84) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932, but subsequently revised and brought more fully up to date.

These earlier workers had recorded sound in the form of a wavy line. To Edison goes the credit for making the record in such a form that it could be used to vibrate a diaphragm and thus reproduce sound. Edison's invention was made in 1876, the earliest patent being dated January 1877. The first records were on a cylinder containing a spiral groove, and covered with a thin sheet of tin foil. A steel stylus was attached to a drumhead of gold beater's skin, much like that of Bell's first telephone. The cylinder was rotated and the stylus, moved by the vibrations of the diaphragm, pressed a groove of varying depth into the tin foil. The same device if allowed to traverse this groove again would reproduce the sound.

Bell and Tainter later studied the various methods and concluded that the rubbing process should be abandoned and an engraving process substituted; that is, instead of pushing the record surface down in a spiral groove as in the original phonograph, it should be dug out or engraved. As a result of their work they obtained a patent on such a device in 1886, and in 1887 produced the graphophone—the first really practical apparatus of the phonograph type.

The record of this machine was a thin pasteboard cylinder covered with wax. Following this, Edison abandoned the tin-foil type of record and adopted the wax cylinder with an engraving process. In 1887, Emile Berliner patented the gramophone. Berliner concluded that the forces required to cut a groove of varying depth were much greater than those available from the human voice without great distortion of the motions involved. He therefore returned to the earlier ideas of Young, Scott, and König, and proceeded to make a laterally cut record. He concluded in addition that it would be much more convenient if these records were in flat or disk form. It is of interest that Edison in his first disclosures also describes the use of a disk, although apparently he did not consider it practical and abandoned the idea.

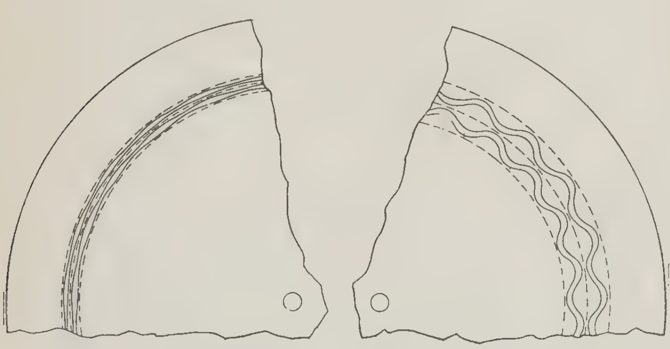
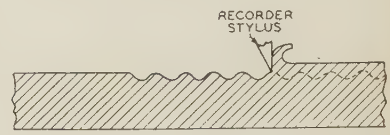


Fig. 1. A schematic comparison, not to scale, of vertically and laterally cut sound records

Berliner engraved his records on metal disks covered with an extremely thin layer of wax. He tried also a mixture of lamp-black and oil to form "a fatty ink which, when crossed by a stylus, shows even under a microscope, a sharply cut transparent line." He recorded with the disk placed above the recording style so that any dust that was formed would fall away. Having thus removed the wax or ink from the surface of the metal, he then etched the disk chemically. Since then, the laterally cut disk record of Berliner has been greatly developed and improved and has been the most commonly used commercial type of record for about 40 years. The very early commercial records were all original recordings; subsequently these were copied by playing from them on to other records, that is, by re-recording. About 1900, Edison rendered the original waxes conducting by sputtering or evaporating gold on to the wax at high voltage in a vacuum. About this time also, fine graphite began to be used to render the original wax conducting. A stamper was plated from the conducting wax and from this a thermoplastic final record was pressed.

Fig. 2. In vertical recording, vertical waves are cut in the recording material



During these early years, many other methods of storing sound were tried. Some of these were optical, some mechanical. For successful operation, however, all of these methods required both a facility in the design and use of vibratory systems and devices not then available.

Electrical recording often was suggested and tried by various phonograph companies, but in general without much success because of the lack of a satisfactory amplifier. Researches and developments in the communication field paved the way for this application, and development studies were carried on by Bell Telephone Laboratories for a number of years. These reached the point of commercial application in 1924 and several companies were licensed to use the improved methods which now have practically displaced earlier methods. In 1926 essentially these same methods were extended to the field of sound pictures.

Since that time, although there has been continued development, no outstanding changes or improvements in disk records have been reported until recently. These continuing investigations now have led to further advance. A highly satisfactory process of cutting and of processing records, and of reproducing from them, has been developed.

Problems to Be Solved

Reproduction from disk records of the past has failed in several ways to meet all requirements either for reproduction in rooms, as in the home, or in large halls or theaters. The most serious fault has been the noise often referred to as needle scratch or surface noise. Other shortcomings in their order of importance have been failure to reproduce all components over a broad frequency range, particularly the higher frequencies; and failure to reproduce an adequate range in loudness, due principally to inability to reproduce weak sounds. This has been caused by the masking of weak sounds by surface noise. Next in importance has come dis-

tortion due to inability of the reproducing needle to follow the record groove accurately. This has been more marked with loud sounds of certain frequencies and has been a minor cause limiting the volume range. The playing time for a record of reasonable size has been rather inadequate and finally the record life has been too short for some otherwise possible applications.

These different characteristics are closely related. Improvement in one is apt to help the others. Consideration of all of these problems has come to indicate strongly the desirability of using a vertically rather than a laterally undulating groove.

Surface Noise

Surface noise is caused by a more or less random distribution of impulsive shocks on the needle due to minute irregularities in the record. It has been common practice in lateral recording to use record

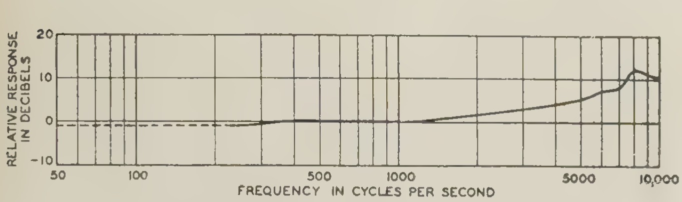


Fig. 3. Energy distribution of surface noise from a cellulose acetate record

material containing a small amount of abrasive in order to grind the needle to fit the groove. Irregularities in the groove due to the abrasive logically would be expected to produce a scratchy noise of a character with which we are all familiar.

Frequency analyses of surface noise have been made using a variety of reproducers and record materials. In general, the shapes of these frequency characteristics have been found to be influenced largely by the resonance characteristics of the reproducers whereas the amount of noise depends on the record. These analyses do not show any marked differences between lateral and vertical recordings. Frequency charts of surface noise taken with a vertical reproducer having a very flat frequency characteristic over the audible range have shown the surface noise to be relatively richer in high frequencies. (See Fig. 3.)

A 5,000-cycle note of the same loudness as a 10,000-cycle band of surface noise from the records whose development is described here, using a reproducer with a flat characteristic, would have a displacement amplitude of only about 0.000001 in.; in order to reduce surface noise so that it is no longer troublesome, irregularities at least down to this order of magnitude must be eliminated. If the usual abrasive record is replaced by an unabrasive record pressed of a clean homogeneous material such as cellulose acetate, surface noise caused by the record material itself is greatly reduced. However, such a change by itself has been found to give a comparatively minor improvement, for when the noise due to the record material is moved well into the background, other causes of surface noise of nearly the same order of magnitude as that due to the abrasive of a shellac record become controlling.

The next process which it has been found necessary to improve has been that for rendering the surface of the original wax electrically conducting. This is necessary in order that the wax may be electroplated to provide a negative with which to press the final record. Usual methods of graphiting or brushing with fine electrically conducting powders have been found unsatisfactory since the individual particles are reproduced in the plated matrix and also the pressed record, thus introducing noise. In addition brushing the wax tends to injure its delicate surface. Recourse therefore has been had to one of the earlier methods used in phonograph practice, namely, cathode sputtering of the wax. (See Cathode Sputtering, by Günther Schulze, *Zeitsch. f. Physik*, April 1926, Aug. 1926.) Graphited and sputtered groove surfaces as seen under a microscope are shown in Fig. 4.

These improvements in methods of engraving, processing, and in the final record material are applicable to either type of recording, lateral or vertical. However, the non-abrasive record calls for a permanently shaped stylus point; there has appeared to be less difficulty in providing this with the vertically cut record. Full advantage of the inherent quietness of these records can be realized only if the frequency range is extended to the full extent thus made possible. In amount the reduction in surface noise from that of present commercial records will differ depending on the frequency range reproduced.

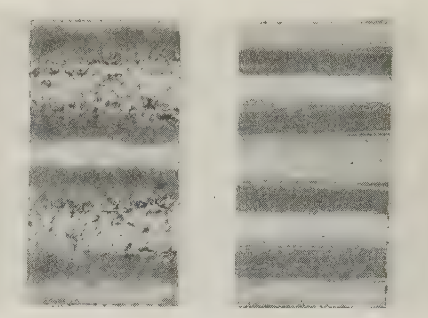


Fig. 4. Graphited grooves (left) and sputtered grooves (right) as seen under the microscope

The microscope is focused on the bottom of the groove

Comparing the new record reproduced with a 10,000-cycle band of frequencies with the old record reproduced with a 5,000-cycle band, which is the comparison of practical interest, shows a reduction in noise of about 15 db. In addition, it is possible to take advantage of the fact that most sounds to be recorded contain less energy in the high frequency range than in the medium or low frequency range ("Speech and Hearing," by H. Fletcher, D. Van Nostrand, 1929) and therefore to record the higher frequencies at somewhat higher than normal level. In reproduction these higher frequencies are, of course, attenuated by the proper amount, in the

reproducing amplifier or circuit. Thus a further reduction of about 10 db in surface noise can be obtained, the amount depending somewhat on the high frequency cut-off of the reproducer or circuit. This effect is chiefly between 5,000 and 10,000 cycles.

Frequency and Volume Ranges Extended

The extension of the frequency range for the recorder is a straightforward problem in design of vibratory systems. With the reproducer the problem is one of designing a system that can be driven accurately by the undulations of the groove without undesirably large forces being set up such as would injure the record. This is largely a problem in reducing the mass of its vibratory system, the solution of which has been found easier with the vertical system. With vertical recording and reproduction the over-all frequency range has been extended thus far to nearly 10,000 cycles.

Volume range for any particular frequency band usually is considered to be the difference in decibels between the loudness of the surface noise and the loudness of the maximum recorded sound that the record can accommodate when reproduced faithfully over this frequency range. The volume range of the laterally cut records of the past when reproduced to 5,000 cycles may be stated as about 25 to 35 db. With vertical recording the volume range for a 5,000-cycle band of frequencies is well over 60 db; for 9,000-10,000-cycle reproduction the volume range is about 60 db. This is very important in reproduction in large halls or theaters where an amplifier and loud speaker of adequate power capacity must be assumed. For reproduction in the home a smaller volume range may be preferred, in which case vertically cut records should prove practically noiseless.

Accuracy of Tracking

In addition to the limitations imposed by surface noise, it is evident that, with the available reproducers for laterally cut records, the needle point may fail to follow the center of the groove accurately when the curvature becomes too sharp and may skid from side to side by varying amounts depending on the record and the characteristics of the reproducer being used. With the lateral groove there is distortion due to the fact that the sound is recorded with a chisel shaped stylus and reproduced with a round stylus, also that in reproduction the bearing point of the stylus against the groove shifts forward and backward as the needle rounds a curve. With vertical records the first of these effects, sometimes called the pinch effect, is absent; but a forward-and-backward shifting of the bearing point of the reproducing stylus occurs if a round tipped stylus is used. For a given stylus tip radius and for a given recording level this effect increases with frequency.

Laterally and vertically cut records drive the reproducer point quite differently. Laterally cut records drive the point symmetrically from both sides, but the point rarely follows the center of the groove with entire exactitude; it deviates from the center by amounts chiefly dependent upon the mechanical impedance of the reproducer. A vertically cut record drives in only one direction. The restoring force is due chiefly to the elasticity of the supporting structure of the reproducer, the normal restoring force being equal to the total weight on the needle minus the weight of the moving or vibrating part. The stylus point always will remain in contact with the record unless forces set up by the record undulations exceed this normal restoring force. Operation always should be below this limiting condition. This sets definite requirements on the mechanical impedance of the vibrating parts and, unless this condition can be met, reproduction of extreme frequencies by vertical records is impossible. With vertical reproducers so far used, however, the stylus can follow sudden downward motions of the record groove even to accelerations greater than a thousand times that due to gravity. Practical experience has shown that the mass of the vibratory system of a vertical reproducer can be reduced so as to reproduce up to well above 10,000 cycles and the stiffness reduced so as to reproduce down to the order of 20 cycles.

With vertically cut records it has been found satisfactory, even where a very loud record is to be made, to use a recording stylus with approximately the same tip radius as used previously in lateral recording. In addition it has not been found necessary to provide any clearance space between grooves. It is feasible therefore to increase the number of grooves per inch from the usual 98 to between 150 and 200 and at the same time to raise the recording level. When using this recording stylus to cut a record with 150 to 200 threads per in. it has been found desirable to make the normal unmodulated groove about 0.007 in. wide and about 0.003 in. deep. Under these conditions, the maximum amplitude may be increased about 4 db. It has been found possible, however, to obtain satisfactory results with most waxes even though the normal depth of the groove is increased to as much as 0.006 in., in which case the recorded level may be increased 6 db. This increase in the recording level obviously increases the volume range by a like amount.

Playing Time of a Record Increased

It has been found desirable with vertically cut records to use a permanent reproducing stylus in order to reduce the vibrating mass of the reproducer to a satisfactory value. This stylus point remains sharp in contrast with the steel needles used with laterally cut records and therefore will reproduce

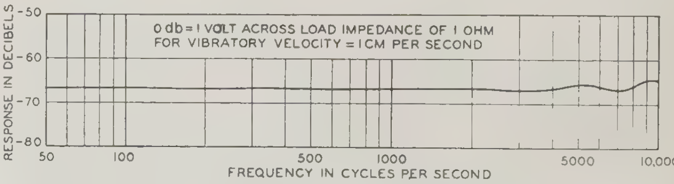


Fig. 5. Response frequency characteristics of an experimental vertical reproducer driven by cellulose acetate records

satisfactorily for undulations of sharper curvature. In other words, over the same amplitudes the linear speed of the record may be reduced. Practically, it may be undesirable to reduce or change the rate of rotation of a record from what has been in use commercially in theater reproduction.

By combining the various elements just mentioned it has been found feasible to record for 15 to 20 min on a 12-in. record and for 10 to 12 min on a 10-in. record. This involves the use of about 200 grooves per in. and a decrease in the recorded level to about the level of laterally recorded records using 98 grooves per in. Of course, longer recordings can be made in the same space if the recorded level is decreased (more grooves per inch) or if the upper frequency cutoff is decreased (decreased rpm and inner diameter). If only speech or music of small loudness range are to be recorded it is feasible to make each face of a 12-in. record play 30 to 40 min. However, such changes may introduce tracking difficulties if carried too far and must be well justified by other considerations if carried beyond these limits.

Great reduction in the mass and stiffness of the vibrating system of vertical reproducers makes it possible to reduce the weight with which the reproducer point bears on the record to between 2 and 20 per cent of that used with most commercial lateral reproducers. This reduction in stylus or needle point pressure decreases the wear on the record

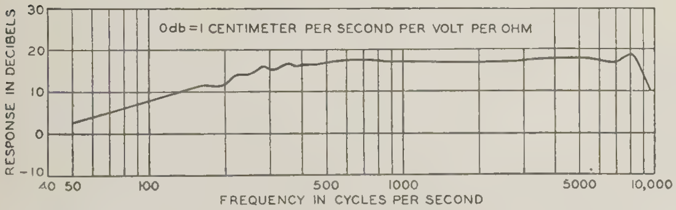


Fig. 6. Response frequency characteristic of an experimental vertical recorder

so that its life has been increased vastly. Tests have shown that the first few thousand playings cause negligible deterioration and even several hundred thousand playings do not show excessive wear if the record is protected properly from dust and dirt.

The Reproducer

A reproducer for vertically cut records which uses a coil of wire vibrated in a radial magnetic field has been found highly satisfactory. Such a reproducer is simple and sturdy. Its performance is linear over a wide amplitude range; it may be made extremely light and, at the same time, is quite efficient. The coils used have had a diameter of between 0.08 and 0.2 in. while the total mass of the vibrating system, including the diamond or sapphire stylus, has varied with different models from 5 to 25 mg. The total force on the record has been reduced from about 150 to between 5 and 25 g, the lighter structure being used when playing from a soft wax. With the larger of these designs it is possible to obtain efficiencies comparable with the efficiency of the Western Electric oil-damped reproducer used with lateral records. When mounted on a simple pivoted arm similar to that used for lateral reproducers, no difficulty has been experienced due to failure to follow the groove. Because of the small mass they operate quite satisfactorily even though the record turn table fails to operate in a true plane and though the record be warped considerably. The response of the moving coil vertical reproducer is practically constant

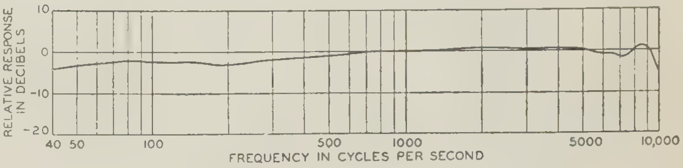


Fig. 7. Over-all frequency response characteristic of recorder + reproducer + network + amplifier

over a broad frequency range as shown by Fig. 5, which is a characteristic taken with cellulose acetate pressings.

The Recorder

Design of a recorder for vertically cut records involves no fundamentally new problems over lateral recorders described previously. (See "High Quality Recording and Reproducing of Music and Speech," by Maxfield and Harrison, A.I.E.E. Trans., v. 45, 1926, p. 334–48.) It is still desirable to design the recorder to approximate constant amplitude characteristic for the lower frequency range and constant velocity for the higher range. The same type of recorder which has been used for lateral recording can be converted for vertical recording by adding a comparatively simple link system. With a few changes in the masses and stiffnesses of the parts it may be given a quite acceptable frequency characteristic. (See Fig. 6.)

Reproducing System Characteristic

Response of the oil-damped lateral reproducer is highest at low frequencies. Its response decreases with increasing frequency, this decrease in the higher frequency range more or less compensating for the increase of response with frequency of the recorder. Because of the flat characteristic of the vertical reproducer, it has been found desirable to compensate in the reproducing amplifier or circuit for the low response of the vertical recorder at the lower end of the frequency scale. A frequency characteristic for the combination of recorder, reproducer, amplifier, and network is shown in Fig. 7.

With vertical records speech is reproduced with improved naturalness and word endings, sibilant sounds, etc., are much more distinct. Sounds from the different instruments in an orchestra, even when playing a loud passage, are reproduced with great individuality and clarity. Results of this sort are difficult to describe and should be heard to be fully appreciated. If records such as those described are

reproduced using various low-pass filters, the elimination of frequencies even above 7,000 cycles is easily noticeable. At the same time little needle scratch or surface noise may be observed with any of these filters, this being almost wholly absent in most cases, whether the records contain speech or music or if blank grooves be reproduced.

Supplementing Natural Resources

Many natural resources either are irreplaceable or may be replaced at an extremely slow rate. Science supplements these resources not only by making possible a more efficient utilization of them, but also by providing acceptable substitutes. This is the sixteenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
H. E. HOWE

Editor, Industrial and Engineering Chemistry

AMERICA has been wonderfully blessed in natural resources. They are the basis of the scale of living which has been achieved in North America. These natural resources, properly utilized through applied science, have resulted in a great number of useful things, a majority of which were not known a century ago; those that were in use at that time were so costly as to be available only to the privileged few. Other parts of the world now are known to have vast resources as yet practically unused. When they are used it will be through the application of science, which takes what is found and from it makes the form or substance required.

Obviously many resources are either irreplaceable or may be replaced at so slow a rate that sooner or later we are brought face to face with serious problems. These problems would be overwhelming but for the ability of science to supplement our natural resources. Science has produced not mere substitutes in the commonly accepted sense of the word, but actual equivalents and sometimes items that are superior to those customarily provided by nature. We would already feel the pinch but for the supplemental resources in the production of which the scientist can properly lay claim to a vast amount of constructive work.

In a certain sense most of the gasoline now burned in internal combustion motors comes from a supplementary source of this fuel. Few crude oils yield more than 15 per cent by volume of gasoline, when those crudes are subjected to a simple process of distillation or stripping; this would not begin to satisfy modern requirements. We have applied physics and chemistry to learn how to break up the larger molecules and to form the smaller ones known as gasoline. Refinements of distillation have been added and methods have been devised to recover from casinghead gas and natural gas those hydrocarbons that could be used for motor fuel. To augment still further the supply of gasoline from crudes the process of hydrogenation at high temperature and pressure has been devised on a commercial scale, so that where economy dictates crude oil can be completely converted into a liquid fuel.

Science Aids in Conserving Timber

A few years ago we all were concerned about the rate at which timber was being cut down for miscellaneous uses. Our hardwood suitable for the distillation and manufacture of wood alcohol, now known as methanol, could be grown at only a fraction of the rate at which it was being cut. Discovery of a method for the synthesis of methanol from gases derived from coal has changed this situation entirely, and indeed has threatened the very existence of the wood distillation industry.

A similar situation existed with regard to lumber. We were told that America was consuming lumber 4 times as fast as it was being produced in the forests. Fortunately this led to an active interest in reforestation and a proper conservation of timber supplies. Almost concurrently, methods were devised for producing a great variety of wall boards not only from waste fibers of the lumber industry, but from other fibers of *annual* crops. These have included sugar cane, cornstalks, oat straw, and similar materials. In the past few years such building boards used for insulation against change of temperature and against sound, and for actual structural purposes, have taken the place of some 15 billion b-ft of lumber. Further research on species of trees once thought unsuited for paper making has resulted in new methods which have extended greatly the possibility of raw materials for this already important industry.

Rapid development in the fixation of nitrogen is a classical example of supplementing natural resources. The story of a possible fixed nitrogen shortage has been told on numerous occasions, and the warning issued doubtless has some influence upon research. Today in place of a shortage there is a world surplus of fixed nitrogen. For either military or agricultural purposes a large number of countries have set up their own synthetic ammonia plants in which nitrogen from the air is fixed with hydrogen produced from coal. At the same

time ammonia from coke plants has been converted into ammonium sulfate for agriculture on a tremendous scale.

Compounds Now Made to Order

Another closely related and classical example is the well-known one concerning coal-tar products. In many directions these compounds have supplemented natural resources. This is true of perfumes, of flavors, of medicines, and, of course, of dyestuffs. In all of these fields products occurring naturally have been outstripped and outnumbered. Today there is little hesitancy in setting out to synthesize any organic compound for which there is a sufficient demand, or, more likely, to produce to order some material required for a special purpose, but not known in nature.

In the field of inorganic chemistry and particularly the metals, we find the least promise of really supplementing natural resources; but even here the application of scientific knowledge has resulted in ways to combat rust and other forms of loss and to combine in some fashion the more abundant resources to supplement those more rare.

Editor's Note: Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.

Amplifier Oscillograph Has Many Applications

IN 2 papers, "Amplifiers for Precise Oscillographic Measurements" (*Journal* of the Franklin Institute, v. 213, June 1932, p. 605–22) and "The Amplifier-Oscillograph Applied to the Study of Dielectrics With Continuous Potentials" (*Physics*, v. 3, July 1932, p. 1–10) Sigmund K. Waldorf, research associate, The Johns Hopkins University, Baltimore, Md., describes the design and construction of the amplifier oscillograph and outlines results obtained in one of its applications. The many interesting applications of this device have included studies of: high voltage wave forms, parasitical corona on high voltage systems, wave forms of magnetic flux in the air gap of an a-c galvanometer, and a-c ionization and d-c charge and discharge currents in insulating materials. In the belief that the device and its uses may be of some possible interest to readers of Electrical Engineering, brief abstracts of the 2 papers are presented herewith.

The first of these papers deals with the general problem of the design and construction of amplifiers for the most accurate oscillographic service. Any amplifier for such work must amplify equally all frequencies within the operating range of the oscillograph vibrator, including continuous currents, and at the same time yield sufficient gain to give the desired overall voltage or current sensitivity. Further, such an amplifier must have a relatively high current output, of the order of 250 to 300 ma at $^1/_4$ volt, as the relatively insensitive "standard" vibrator must be used for its superior reproduction characteristics. Lastly, an amplifier to be used with an oscillograph must possess steadiness quite beyond that required in other types, as an oscillographic record might easily be spoiled by a slight unsteadiness for a small fraction of a second, which would pass entirely unnoticed in a speech amplifier or similar device.

The specification that the amplifier be effective with continuous currents as well as alternating at once limits the circuit to the pure resistance coupled type. Also, tests have shown that this is the only type of circuit that will give reproduction of the high quality requisite for precise measurements, and that only when 3-electrode tubes having high amplification factor are utilized for the voltage amplification stages. A satisfactory output stage was obtained with 6 low impedance, low voltage, 3-electrode tubes in parallel. Several circuits for compensating for the steady component of the output plate current were investigated both theoretically and experimentally, and the simple arrangement of a resistance and a battery in series shunted across the oscillograph vibrator was found to be the most suitable. It is interesting to note that for the least impairment of vibrator sensitivity by the compensating circuit, the compensating battery voltage and accompanying resistance should be relatively large.

For amplifiers of this type, in common with some of the more familiar types, effective shielding and grounding are of utmost importance. A not insignificant factor in precise oscillographic measurements is the distinctness of the oscillographic record. By observing the more fundamental principles of photography, excellent oscillograms can be obtained at film speeds of 25 ft per second with an incandescent lamp for a light source.

It is with the special technique required for the accurate measurement of d-c charge and discharge currents of dielectrics that the second paper deals. For the correlation of the d-c properties of dielectrics with their a-c losses, the continuous currents flowing must be measured as soon as possible after the d-c voltage is applied to or removed from the specimen. With the apparatus and method developed, observations could be begun within 0.001 or 0.002 sec after the specimen had had the d-c voltage applied, or had been short-circuited, and could be continued as long as desired. Thus, a connected series of observations was obtained with a single cycle of voltage application, removal, and short-circuiting of the specimen. This greatly expedited the work and eliminated inaccuracies that hitherto had entered into such measurements because of changes in the dielectric sample during the long periods of time heretofore required. The apparatus consisted prin-

cipally of a quick-acting, spring-actuated switch for operating the specimen circuits rapidly, and a sensitive amplifier-oscillograph. In operating, the quick-acting switch shunted the geometric charge of the specimen to ground for a brief interval after applying voltage to the specimen, or short-circuiting it, and then connected the amplifier-oscillograph to the measuring circuit. The observations could be continued as long as desired with a D'Arsonval galvanometer of high sensitivity. The amplifier-oscillograph attained a voltage sensitivity of 1.6×10^{-3} volts, or current sensitivity of 1.6×10^{-8} amperes, per mm deflection. This current sensitivity is about 300,000 times that of the oscillograph alone, and was accomplished with a 3-stage amplifier, pure resistance coupled.

A Method of Control for Gas Filled Tubes

The most commonly accepted general method of controlling 3-electrode gas-filled tubes is by shifting the phase of the grid voltage relative to that of the anode voltage. An alternative general method which may be termed the condenser-discharge method has proved highly satisfactory in a variety of applications. Several examples of this type of control are described in this article.

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MOST of the methods heretofore published for controlling the grid-controlled gas-filled rectifier tube of the hot cathode type, involve application of either d-c voltage or sine wave a-c voltage to the control grid. For many applications this is the simplest and most desirable method. It has been found, however, that some problems can be attacked most successfully by applying to the grid what might be termed repeated-transient voltages. These voltage variations are brought about by charging a condenser during some part of each cycle through a rectifying circuit, and then allowing the condenser to discharge freely through a circuit containing either resistance alone or a combination of resistance and inductance. In this process, a separate rectifier may be used in the charging circuit, or the rectifying property of the cathode-grid circuit of the tube being controlled may be utilized in order to avoid the necessity for a separate rectifier.

Principles involved in the condenser-discharge control are best explained by describing a variety of typical examples. The principle of the more conventional phase-shift control referred to is illustrated in Fig. 1; this is included in order to bring out the distinctions between such control and the condenser-discharge methods subsequently described. In Fig. 1A is represented the relation of anode voltage and grid voltage in control of the type in which anode current is allowed to pass for an adjustable percentage of the positive half cycle of anode voltage; *B* shows the variation used to obtain sharp-cutoff control, it being evident that at about the condition shown, a slight shift in phase of the grid potential results either in current being allowed to pass for substantially all of the positive half cycle of anode

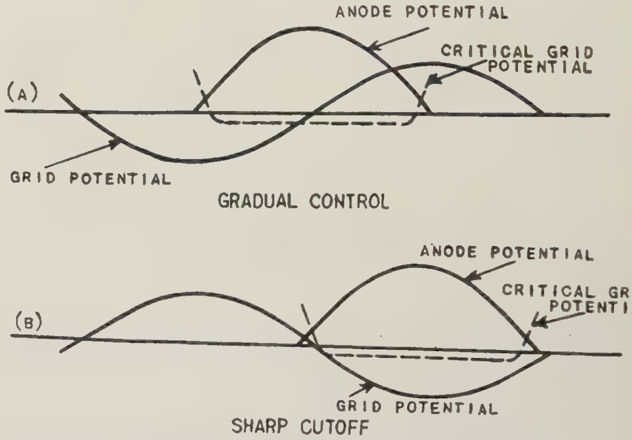

Fig. 1. Voltage relations in phase-shift control of 3-electrode gas-filled tubes

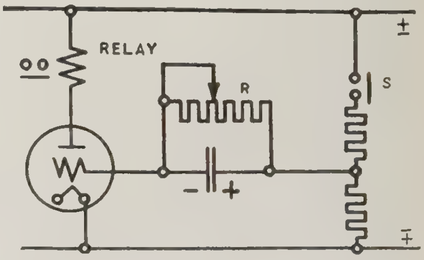

Fig. 2. A simple condenser - resistor timing circuit

Prepared especially for ELECTRICAL ENGINEERING; includes essential information contained in a paper, "A General Method of Gaseous Tube Control" (No. 32M6) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

voltage, or, alternatively, not being allowed to pass at all.

In control systems using the method of Fig. 1, it is necessary that the controlling element in some way effect phase shift of the grid voltage; this can be done readily in certain instances, but presents difficulties in others. In straight manual control there is no difficulty, as a hand operated rheostat or phase shifter can be provided. There are also many ways of getting an automatic response to circuit conditions in the form of a shift of grid voltage. However, in some applications of automatic control it is difficult to get the controlling element to cause a phase shift of grid voltage with sufficient sensitivity, or even at all. Notable instances are in the attempt at gradual control by voltage amplitude derived from cascaded potentiometers in theater dimmer control, and in the use of this type of tube as an amplifier for photoelectric cells. The difficulty in the former case lies in trying to translate a voltage amplitude into a phase shift; in the latter, it lies in the rectifying property and high impedance of the photoelectric cell.

Examples of Condenser-Discharge Control

The basic idea of the examples to be described is that of electrostatic energy storage in the grid circuit, taking advantage of the rectifying property of the cathode-grid circuit. The simplest form is that of the simple condenser-resistor timer shown in Fig. 2. The condenser tends to hold a charge as indicated so long as switch S is closed, and loses its charge in definite time through R when S is opened. Throughout most of this discharge period, which is adjustable, the grid is sufficiently negative to block conduction through the tube. The circuit, therefore, provides an accurate definite-time relay having the properties of wide range and extreme ease of adjustment. Figure 3 shows a commercial relay based on this principle, which has been used extensively in resistance welding and also to some extent in X-ray timing and miscellaneous uses. There is an evident analogy between the timer of Fig. 2 and the timing of the inverter circuit shown as Fig. 4. This inverter circuit follows the well-known plan of taking current from a d-c source alternately through 2 transformer primary windings in such a way as to induce an alternating voltage on the secondary winding. The action of the condenser C_a connected between the anodes in stopping conduction in either tube when it starts in the other is well known. It is necessary to point out only that grid condensers C_1 and C_2 take alternate charges like those assumed by C_a, the difference being that when, say, conduction in tube A is stopped by C_a, the negative charge on the grid side of C_2 can leak off only through r and L and around through tube B to the other plate of C_2; this requires a definite time. Introducing inductance into the discharge paths of C_1 and C_2 prevents asymptotic approach of condenser voltage to zero and insures positive timing.

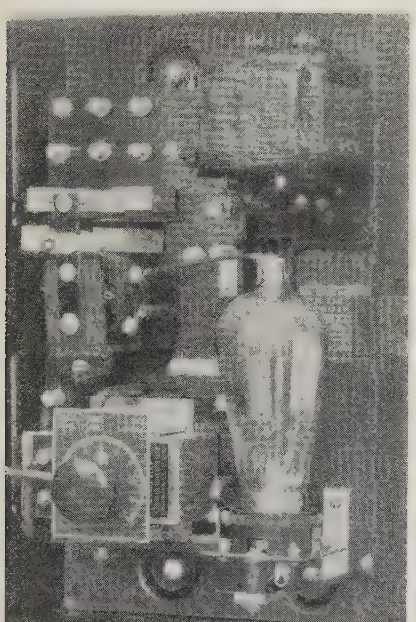

Fig. 3. A definite-time relay used in resistance welding, based upon the circuit of Fig. 2

An adaption of the circuit of Fig. 4 is shown in Fig. 5. This is a method of regulating the average current flow in a d-c circuit, suitable for such applications as the regulation of d-c field current. Tubes A and B conduct alternately, the time that tube B conducts depending on the adjustment of potentiometer r, or reciprocal adjustment of condensers C_1 and C_2. Tube B thus acts substantially like a vibrating contact across resistor R_1.

Figure 6 shows the condenser-discharge method of controlling the point at which current is allowed to start in a positive half cycle when an alternating voltage is applied to the anode of the tube. During each negative half cycle, the condenser is charged negatively on the grid side by the voltage E_c, taking advantage of the rectifying action of the auxiliary electrode shown in the tube. Discharge then takes place through resistor r as shown in Fig. 6B; the point of starting the arc in the tube is adjustable by

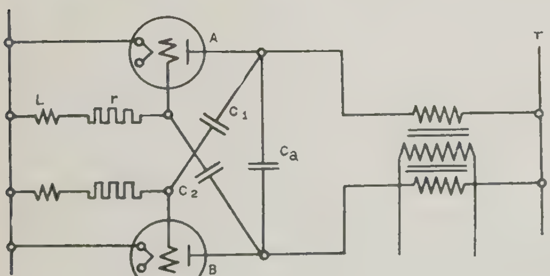

Fig. 4. (Left) Inverter circuit using the condenser - discharge method of control

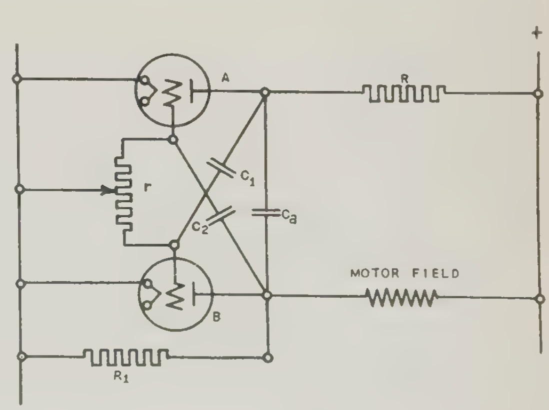

Fig. 5. (Right) An arrangement for regulating the average current flow in a d-c circuit

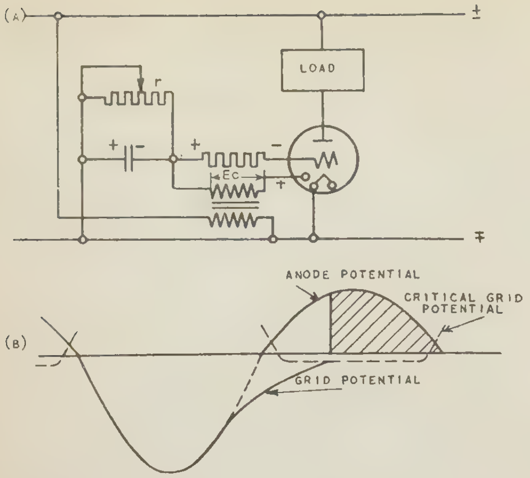

Fig. 6. (Left) Condenser - discharge method of controlling the point at which current is allowed to start in a positive half cycle when an alternating voltage is applied to the tube anode

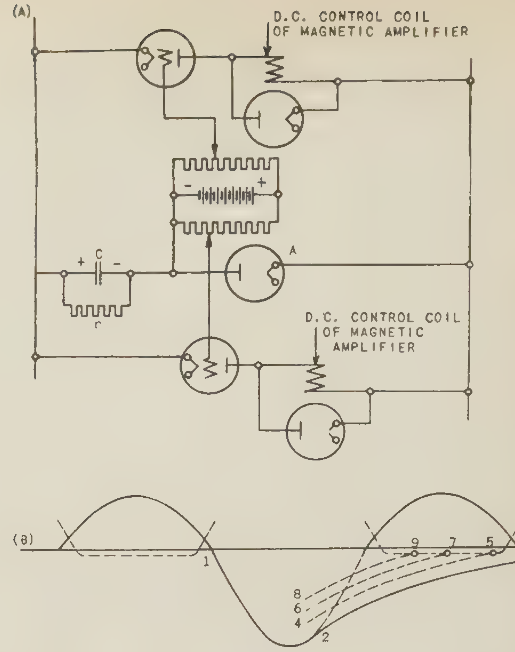

Fig. 7. (Right) Circuit of Fig. 6 adapted to theater dimming control

varying either C or r, or the amplitude or phase of E_c. Inclusion of inductance in series with r causes the discharge curve to intersect the curve of critical grid potential at an angle favorable to stable operation in spite of the shift in tube characteristic.

In theater dimmer work it is customary to use the tubes as rectifiers controlling the d-c control currents of the magnetic amplifiers (reactor type dimmers). Here any reactor must be controlled either from its individual potentiometer, or from a master potentiometer from which several other reactors derive their control. In Fig. 7 is shown how the general principle of Fig. 6 may be adapted to dimmer control. Rectifier tube A, condenser C, and resistor r provide a basic wave 1–2–3 which is part of the voltage applied to all of the grids of all the reactor control tubes. Superimposed on this wave in the grid circuit of each control tube is d-c voltage derived from its individual potentiometer (or several control tubes may be switched to a single master potentiometer) giving control curves 4–5, 6–7, etc., depending on the potentiometer bias. Similar biasing control may be applied to the sinusoidal grid potential wave of Fig. 1A, but it is evident that the shape of this wave is inferior for this purpose to the curve 2–3 of Fig. 7B.

Thus the arrangements shown in Figs. 6 and 7 are not merely substitutes for phase shift control, but constitute a method which, in contrast to phase-shift, is directly and in a simple way responsive to either a-c or d-c voltage control. Moreover, since r in Fig. 6A has to conduct only in one direction, this circuit is adapted directly to photoelectric cell control of the average current in the gas filled tube.

Sharp Cutoff by Condenser-Discharge Control

The two other members of this family of condenser discharge control methods that will be described herein belong to the short-cutoff class typified by Fig. 1B. Before describing them it will be well to digress momentarily in referring to Fig. 8; A shows a typical set of characteristic curves of a hot-cathode grid-controlled mercury-vapor tube, while B shows the same replotted in terms of half-wave voltage applied to the tube anode.

Regarding the curves of Fig. 8A it should be

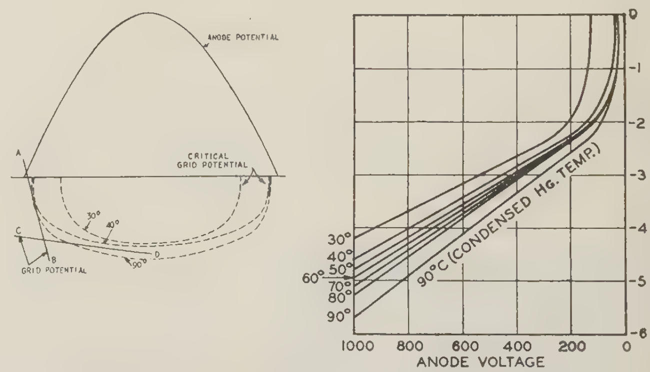

Fig. 8. Characteristics of a hot-cathode grid-controlled mercury-vapor tube

noted that, although the control characteristic varies considerably at different condensed-mercury temperatures, there is not nearly such wide variation in the anode voltage at which an arc will start with zero grid potential. In fact, for 50 to 90 deg C condensed-mercury temperature, which includes the ordinary operating range, the curves practically coincide at this point and in its neighborhood. This fact makes possible quite stable sharp-cutoff control, provided instantaneous grid control voltage can be introduced with some such slope as A-B of Fig. 8B as contrasted with slope C-D. This principle is the basis of the satisfactory operation obtainable by the method of Fig. 1B. This principle is used also in the 2 examples of sharp-cutoff by condenser-discharge control to be described.

In the control of slip ring induction motors driving newspaper presses, it is often necessary to have available a relay that is accurately responsive to a definite motor speed. One way to provide this is by having the relay respond at a given frequency which, of course, is related definitely to the motor speed. Figure 9 shows an arrangement (introduced by G. C. Brown of Cutler-Hammer, Inc.) that gives this result in that tube I is conductive only at fre-

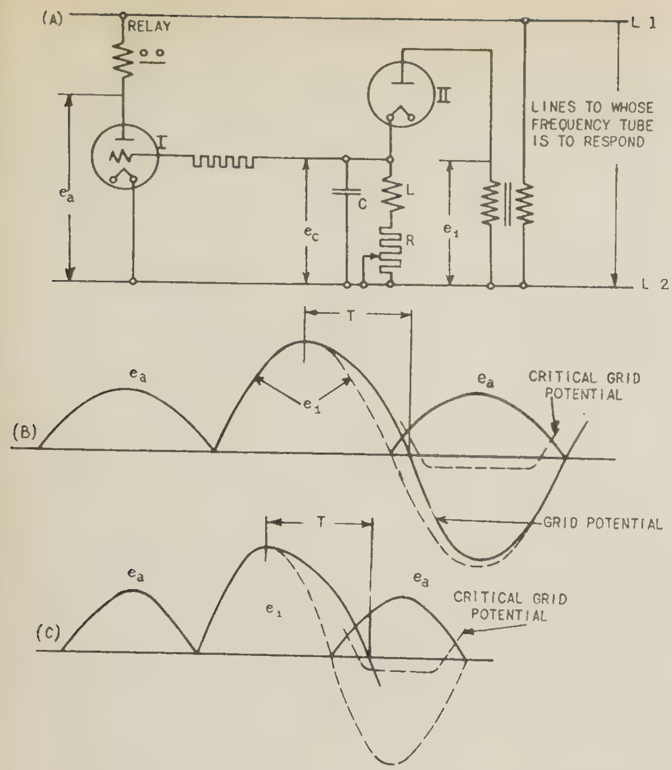

Fig. 9. A relay circuit which responds at a definite frequency

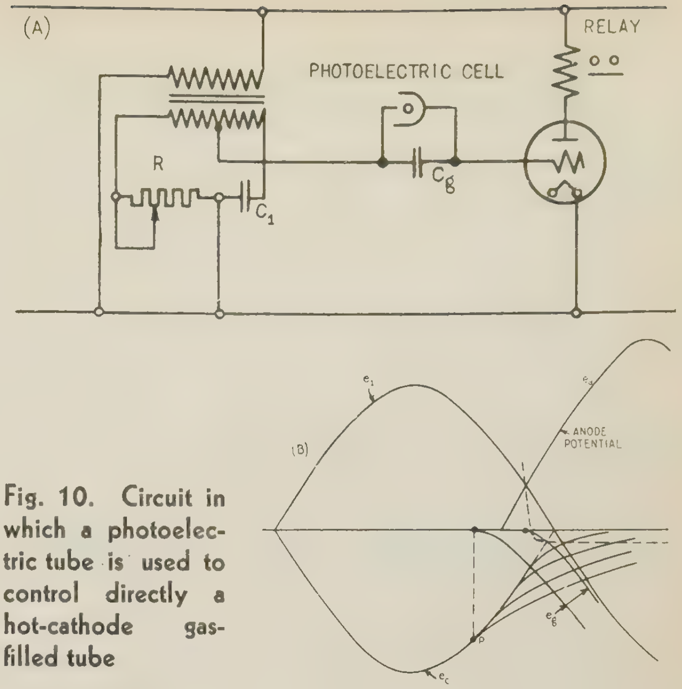

Fig. 10. Circuit in which a photoelectric tube is used to control directly a hot-cathode gas-filled tube

quencies above a critical value. As indicated in Fig. 9B, the a-c voltage e_1 is used to charge condenser C through rectifier tube II during negative half cycles of the anode voltage. Although the condenser voltage e_c substantially equals e_1, while the latter is *increasing* (neglecting the small arc drop in tube II) e_1 can *decrease* more rapidly than e_c, due to the rectifying action of tube II. Therefore, e_c decreases in accordance with the natural discharge period T of C through L and R. Evidently, at a frequency lower than the critical frequency (Fig. 9B) T is not sufficient to permit tube I to conduct, but is sufficient at higher frequencies as shown in Fig. 9C. This arrangement is being used commercially on newspaper press controllers.

Although in the past several arrangements have been designed for direct control of the gas filled tube by means of a photoelectric cell, such arrangements in general have not been commercially practical for several reasons. The methods of including the photoelectric tube in the circuit were such that:

1. A large percentage change in photoelectric current was necessary to change the grid potential of the gas filled tube sufficiently to accomplish the control. In other words, the circuit was relatively insensitive to changes in illumination of the photoelectric tube.

2. Variation in the control characteristic of the gas filled tube seriously affected the accuracy of the control.

3. Grid currents obtained in the gas filled tube were a disturbing factor making difficult the control by currents so small as those of a photoelectric tube.

In view of the foregoing, in the past it has not been considered advisable to control the hot-cathode gas-filled tube directly by a photoelectric tube, hence the practice of interposing an amplifying tube has been adopted. However, the simple arrangement of Fig. 10 overcomes the objections outlined, and has been operated successfully in industrial applications for a sufficient period to prove its practicability. In Fig. 10, R and C_1 form a phase-shifting bridge, giving voltage wave e_1 of Fig. 10B, which is adjustable in phase with reference to e_a. During positive half cycles of e_1 a charge is drawn to the grid side of C_g, through the cathode-grid circuit, the opposite (and approximately equal) condenser voltage being represented by the wave e_c. As e_c falls off from its peak value (due to the discharge of C_g through the photoelectric cell) a point P is reached at which e_c no longer can reduce as rapidly as e_1, since C_g cannot discharge back through the cathode-grid circuit, but can discharge only through the photoelectric cell. Up to this point the grid is at approximately cathode potential (slightly higher during the process of charging C_g); but beyond P the voltage e_c has a greater absolute value than e_1, so that there is a net negative potential on the grid as represented by e_g. From the curves it is evident how variations of photoelectric cell resistance vary the phase position of the e_g curves. This shift is sufficiently great for a given percentage change in photoelectric cell resistance to meet practical requirements. As would be expected from the considerations brought out, this method gives stable direct control of a mercury vapor tube by a photoelectric cell, in contrast to the instability experienced when this is attempted by other known methods.

One of the difficulties experienced with hot-cathode gas-filled tubes has been the tendency of the grid to emit thermionically, which results in weakening or loss of grid control. This condition has been aggravated in many cases by the deposition on the grid of the emission-increasing material from the cathode, while the tube is in service. Experience of engineers working with these tubes has been that this tendency was less pronounced in circuits where the grid was made strongly negative during some part of the cycle in which an arc was passing between

anode and cathode. This is thought to be due to a mechanical cleaning action of the grid by positive ions striking it when attracted to it under the conditions described. This desirable circuit condition is met in the arrangements of Figs. 9 and 10, and doubtless partly accounts for the highly satisfactory industrial operation which has been experienced with these arrangements.

Mercury Rectifiers Vs. Rotary Converters

This article discusses 4 years' experience in the operation of unattended automatic mercury arc rectifier and rotary converter substations supplying 600-volt d-c energy to overhead trolleys in interurban territory. The seriousness of minor failures in control equipment ordinarily employed in automatic stations is emphasized, and the replacement of some integral parts of automatic station control systems with more reliable equipment is recommended.

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BEFORE beginning a discussion and comparison of synchronous converters and mercury arc-rectifiers, consideration will be given to what may be considered reliable service. Reliability is, of course, relative and varies for different kinds of service, as well as for different localities. In general, during the past few years there has been a marked improvement in performance reliability of automatic control; however, further improvement should be made if automatic control is to be substituted for manual control of conversion equipment, except where automatic control results in lower operating costs. It is possible for unattended automatically controlled stations to show considerably less failures per operation performed than manually operated stations, and still the service rendered through manually controlled stations may be the superior of the 2. Operating experience of The Milwaukee Electric Railway and Light Company indicates that service availability of manually controlled equipment is slightly greater than that of automatic substations.

Most faults resulting in service failure in substation equipment can be repaired easily and quickly; if they are of the cumulative type, requiring some time to develop, in some cases days before actual failure occurs, the attendant at manually operated stations usually makes repairs with little or no delay, or notices the potential faults and corrects them without inconvenience to or knowledge of the ultimate consumer. This is really the important thing to consider. Similar abnormal conditions in an unattended automatic substation may, and in fact often do, cause prolonged machine or other equipment outages.

Failures of small and relatively unimportant equipment, such as fuses, relays, and resistor units, in automatic substations are much more serious than the failure of similar equipment in manually operated stations. Many standard commercial articles are not suitable for use in automatic stations, for example, the fuse; occasionally one will open up for no apparent reason. Ordinarily this is a matter of little inconvenience and is not worth much of an expenditure to correct. For general average purposes, the present day fuse appears to be reliable enough and there appears to be no reason for suggesting the redesigning of it. In an attended station, an open fuse rarely affects service to customers, but in automatic stations, such an occurrence often results in service outage. To people sitting in darkened homes, climbing stairs because elevators are out of commission, or standing extra minutes on corners, perhaps in sub-zero weather, waiting for street cars, the degree of inconvenience suffered varies little, whether the delay is a direct result of some major equipment failure or of the opening of a 5-cent fuse.

Other pieces of equipment that may be included with fuses in the list of undesirables for automatic stations are some standard relays and small resistor units, particularly those in circuits normally energized. In a general way, relay troubles may be divided into 2 classes:

1. Relay windings and contacts are not sturdy enough, or they are

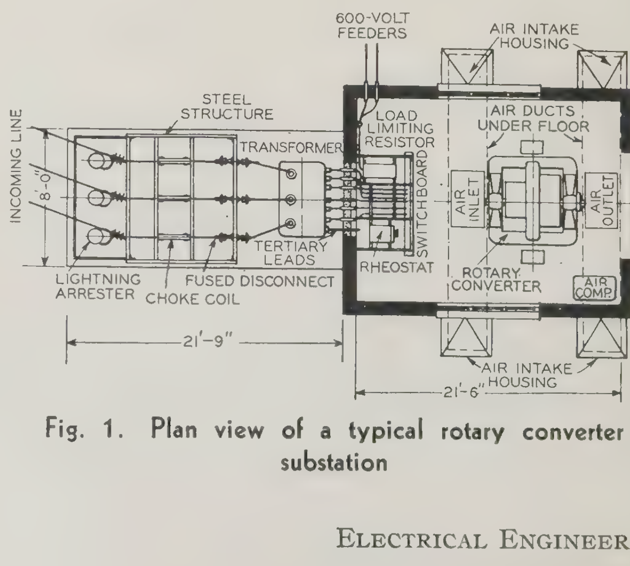


Fig. 1. Plan view of a typical rotary converter substation

This article contains full text of a paper of similar title presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932, but supersedes that paper in that it contains operating data for one additional year; available in published form only in ELECTRICAL ENGINEERING.

not sufficiently protected to withstand abnormal circuit conditions brought about by lightning or voltage surges due to other causes.

2. Sufficient attention is not given to securing bolted connections to prevent their loosening. Resistor unit failures appear to be due to improper control of material during the manufacturing process. It is desirable to replace, in so far as is practicable, unsatisfactory standard equipment with something more reliable. Manufacturers should share this responsibility with operating companies.

The preceding comments and suggestions pertain to control systems in general; they apply equally to rotary converter and mercury arc rectifier substation control systems.

The Milwaukee Electric Railway and Light Company has in service 3 550-kw, 600-volt single-unit fully automatic mercury arc rectifier substations, each having a guaranteed overload rating of 25 per cent for $^1/_2$ hr; 50 per cent for 3 min; and 100 per cent for $^1/_2$ min. These substations were placed in service in 1927 and supply energy to a section of an interurban line. There are also in operation on the Milwaukee system several fully automatic 500-kw 600-volt rotary converter substations in similar service. These stations were placed in service early in 1928. Some of the synchronous converters are guaranteed to carry momentary overloads of 100 per cent and others 200 per cent without injury; each of them has a 50 per cent overload rating for 2 hr.

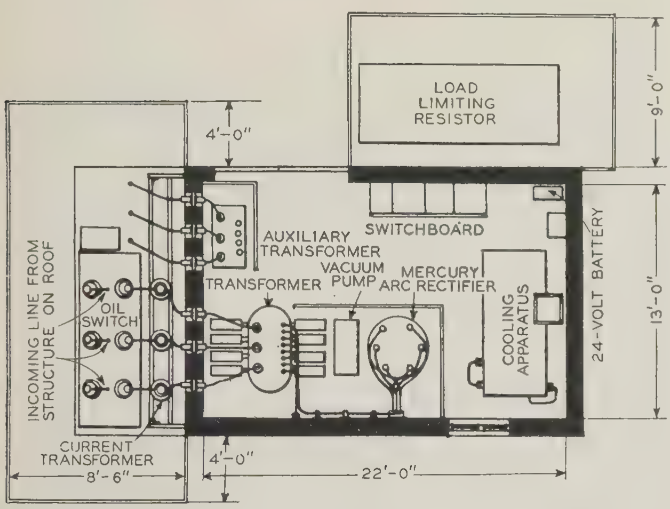


Fig. 2. Plan view of a typical mercury arc rectifier substation

Records of service availability of both rectifiers and converters have been maintained since the different stations were put in service; however, these data alone were of little value in preparing operating expenses for the different types of converting equipment. Since such a comparison appeared advisable, a special accounting procedure for collecting the necessary data was initiated about 18 months after the rectifiers were installed. In a majority of automatic equipment installations, records indicate that more faults developed in the first year's operation than in any succeeding 12-month period. As stated previously, the rectifier substations were completed and put in service early in 1927. Operating expense for the first year is not included in the figures, the reason being that it is not available. Cost figures for the first 6 months of operation for the rotary converter stations also are not available. Therefore, delays resulting from minor faults during starting periods are not included in either case.

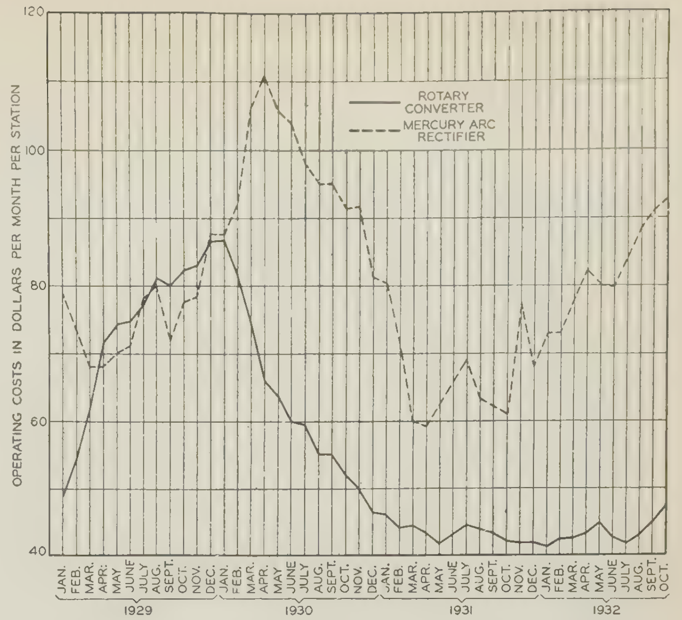


Fig. 3. Operating costs of comparable rotary converter and mercury arc rectifier substations

Traveling time of interurban substation inspectors is a fair-sized portion of the total time of each inspection trip. This fact was given consideration in selecting rotary converter substations for comparative operating data so that the converter stations discussed are about the same average distance from the headquarters of the men responsible for their maintenance as are the rectifier stations. Neither of the synchronous converter substations chosen nor the rectifier stations supply other than 600-volt d-c service for interurban train operation. All are single-unit substations. The men responsible for operation and maintenance are, as nearly as can be determined, of equal ability. The comparison is believed to be a fair one and the results obtained are fairly accurate in indicating the reliability of service, as well as operating expense, of small substations converting 60-cycle a-c to 600-volt d-c energy.

By far the most prevalent cause of failures in rectifier substations resulted from ignition or excitation faults. These nearly always caused burnouts of either or both of the ignition and excitation relay coils. On the units under consideration, it is necessary to open the tube tank with corresponding loss of vacuum in order to replace ignition rod springs which almost invariably were annealed when the ignition coils failed. This operation necessitates keeping the unit out of service for at least 24 hours in order to re-establish a satisfactory vacuum within the tube tank.

After considerable study of rectifier failures, it was learned that under certain conditions during starting periods the ignition anode became a cathode; this established a circuit through the excitation coils to the trolley. With this circuit completed, the excitation coil soon burned out, thus energizing the ignition

coil continuously and this coil then was overheated to failure within a few minutes. To overcome this difficulty, the control wiring was changed to prevent closing the d-c circuit breaker and the high voltage oil circuit breaker until after excitation is established. As stated previously, ignition and excitation troubles were the cause of a great majority of service outages before the change in control wiring was made early in 1930. This source of trouble has been eliminated by the present scheme of wiring; since the change was made no coils have been burned out in either the excitation or ignition relays, and no ignition rod spring trouble has been experienced.

Curves in Fig. 3 graphically show the average operating expense of the 2 types of stations under discussion. Figures given as dollars per month are 12-month averages, with the exception of the first 5 months of 1929 when previous 12-month data were not available; figures for January 1929 are for 7-month averages, February, 8-month, and so on up to May where they are based upon 11-month averages. The rise in operating expenses of rectifier stations to a value of approximately $112 per month in April 1930, and the subsequent drop, is explained by the ignition and excitation troubles previously referred to, and which were corrected early in 1930. The rise during 1932 of rectifier operating expense is due principally to gasket failure and gasket replacement. These units then had been in service about 5 years, which time appears to be the maximum life that can be expected of the present type rubber gaskets. An expenditure of approximately the amount shown for 1932 together with the resulting out-of-service time therefore may be anticipated, at least every 5 years. The increase during 1929 in synchronous converter operating expenses is the result of d-c riser troubles in one machine and shunt field failures in the other machine.

Table I summarizes rotary converter failures, while Table II contains similar information for the 3 mercury arc rectifiers. It may be noted that the average time per year a rectifier is not available for service is almost 30 times greater than the non-available time of rotary converters during this 4-yr period. A great improvement in service availability of rectifiers was effected when the ignition and excitation troubles were corrected in 1930; this improvement is clearly indicated in the 1931 record when the average number of failures dropped from a previous 2-yr average of 6.6 failures per unit per year to an average of 3.3 failures per unit in 1931. The improvement in outage time during 1931 as compared with the 2 previous years is more impressive. During 1929 and 1930, the annual service outage per station amounted to 213 hr and 57 min; in 1931, this figure dropped to 98 hr and 23 min. A transformer failure at Nemahbin substation was responsible for 264 hr outage. Had it not been for this trouble, the 1931 rectifier record would have compared favorably with rotary converter operation. The 1932 increase is a result of gasket replacement previously referred to. It is quite evident that the synchronous converter stations have the better performance record.

Rectifiers are more efficient than synchronous converter units, but no material saving is effected in 500-kw stations supplying energy for interurban systems where the average output is somewhere between 40,000 and 50,000 kwhr per month per station. It is apparent, therefore, that the cost of energy saved by reason of the more efficient converting equipment will just about amount to the difference in operating expense, as indicated by the costs for 1931 given in Fig. 3.

Conclusions

In arriving at conclusions after comparing operating records of rectifier and synchronous converters covering a 4-yr period, it is manifestly unfair to neglect the fact that these rectifier stations were the first, or if not the first, among the earliest installations with full automatic control in unattended substations. Full automatic rotary converter stations had been in service many years. Proceeding with this in mind, the records indicate that under conditions of operation existing in the Milwaukee interurban territory:

1. Operating and maintenance costs of the mercury arc rectifier are higher than those of the rotary converter, but this is compensated to some extent by the higher efficiency of the rectifier.
2. Service availability of converters is greater than that of rectifiers when the converting equipment is unattended and is equipped with automatic control.
3. An improved rectifier gasket with longer life is highly desirable and should result in better operating performance.
4. Control system failures in whole or in part are vastly more serious in automatic than in manually controlled stations.
5. More attention should be given to the prevention of faults in auxiliary relays, operating coils, protective equipment, etc., used in automatic control systems.

Table I—Rotary Converter Service Failures

Year*	No. of Failures	Time Not Available for Service	Average Outage Per Failure
1929	4	13 hr 20 min	3 hr 20 min
1930	12	34 hr 10 min	2 hr 51 min
1931	2	3 hr 0 min	1 hr 30 min
1932	1	2 hr 10 min	2 hr 10 min
1929–32, inclusive	19	52 hr 40 min	2 hr 46 min
Average number of failures per station per year			2.4
Average time station was not available for service per year			6 hr 35 min
Average duration of outage per failure			2 hr 45 min

* Year 1929 includes Nov. and Dec. of 1928, in addition to all of 1929; year 1932 does not include Dec. 1932.

Table II—Mercury Arc Rectifier Service Failures

Year*	No. of Failures	Time Not Available for Service	Average Outage Per Failure
1929	28	962 hr 53 min	34 hr 23 min
1930	12	320 hr 49 min	26 hr 44 min
1931	10	295 hr 8 min	29 hr 30 min
1932	14	842 hr 2 min	60 hr 87 min
1929–32, inclusive	64	2420 hr 52 min	37 hr 48 min
Average number of failures per station per year			5.25
Average time station was not available for service per year			201 hr 44 min
Average duration of outage per failure			37 hr 48 min

* Year 1929 includes Nov. and Dec. 1928 in addition to all of 1929; year 1932 does not include Dec. 1932.

News

Of Institute and Related Activities

Reports of Committee Meetings Held During Winter Convention

MEETINGS were held by many of the Institute's general and technical committees during the winter convention held in New York, N. Y., Jan. 23–27, 1933. Proceedings of these meetings are summarized in the following paragraphs, excepting only (1) the standards committee meeting, the results of which are reported under the "Standards" department of this issue, and (2) those committees for which no report has been made available for publication; this latter group is composed of the following: education committee, electric welding committee, and the subcommittee on distribution.

Student Branches

At the meeting of the student branch committee and counselors a subcommittee was appointed to report to the delegates meeting at the annual summer convention in Chicago Ill., in 1933 on the problem of readjusting the set-up of the student branches. At present it is necessary for the branches in many engineering colleges to have a local membership fee of $1, in order to meet the expenses of operating the branch. These local members are not affiliated with the Institute. It is hoped that some plan may be devised which will emphasize obtaining enrolled Students of the Institute rather than local members. One of the primary objects of forming student branches is to get students in electrical engineering connected with the Institute and acquainted with its policies, ideals, and methods of procedure.

At the Cleveland meeting of the counselor-delegates it was voted to recommend that the Institute refer to the engineer's council for professional development that it take up the problem of rating the engineering colleges of the country. It was a great source of satisfaction to the delegates present to note that a committee had recently been appointed by the council to undertake this most important work.

Technical Program

A large part of the technical program committee meeting was devoted to the consideration of plans for the 1933 summer convention to be held in Chicago, Ill., June 26–30, 1933. In accordance with custom, it is proposed to restrict technical sessions to morning meetings, leaving the afternoons free for visits to the Century of Progress Exposition, sports, and other activities. Monday, the first day of the convention, will, as usual, be devoted to the formal opening of the convention and to conferences of officers, delegates, and members. On Wednesday morning the A.I.E.E. is to participate in a joint meeting with a number of engineering societies who will be holding conventions in Chicago during the same week. There will be no technical sessions on either of these 2 days. For the mornings of the remaining days, Tuesday, Thursday, and Friday, a number of unusually interesting papers covering many of the fields of electrical engineering are in prospect, including an address on engineering education. Provision will, of course, be made in the program for the customary address by the president of the Institute.

Plans for the Pacific Coast Convention also were discussed. At this convention it is tentatively proposed to have 4 technical sessions devoted to papers covering a variety of subjects including transmission, communication, protective devices, research, and applications of electricity to mining work.

The committee considered several suggestions relative to the provision of small meeting rooms during conventions wherein an author might meet informally with those interested for a more extended discussion of his paper than is possible during the usual technical session. There was some consideration also given to the question of encouraging and scheduling in advance of a convention, intimate and informal round table meetings for discussions of specialized branches of the art. It was contemplated that each meeting of this sort would be addressed at some length by an expert in the topic to be discussed and would provide ample opportunity for a full exchange of views, questions, etc. Two meetings of this kind held during the last winter convention, on sound measurement and on the professional development of the engineer, proved to be both popular and highly instructive. The committee is studying these proposals with a view toward their further application at subsequent conventions.

Automatic Stations

Several members of the committee on automatic stations stated that much interest was being shown throughout the country concerning automatic reclosing schemes that were instantaneous or extremely rapid. The manufacturers recently have perfected relays and devices to allow the oil circuit breaker to reclose as rapidly as the inertia of the breaker will allow and, there have been several installations made in various parts of the country. It was decided to collect further information on this subject with the intention of appointing a subcommittee to study the problem and if possible arrange the data in some form for presentation to the Institute.

There appeared to be a need of describing and outlining the various devices and schemes in general use and available for centralized load dispatching systems. It was thought that this would be a great help to engineers working on such problems and contemplating centralized operation. A subcommittee will probably be appointed to study this subject.

Several suggestions have been received regarding a revision in the standards on automatics and a subcommittee was appointed to check over the suggestions to submit at the next committee metting. A suggestion was received that a paper or study on automatic street lighting would be of general interest. This is being checked among the members of the committee and, if desirable, will be undertaken shortly. It was decided that this committee would not request a session at the coming Summer Convention in Chicago.

Electrical Machinery

At the meeting of the electrical machinery committee, reports were submitted on the status of the test codes. The transformer test code is being revised, the preliminary test code on synchronous machines is in the hands of the printer, and the test codes on induction machines and on d-c machines are being developed.

The synchronous machinery subcommittee has prepared a table for the American Standards Association on 40 deg C special purpose synchronous motors and has prepared some comments on test code No. 6 of The American Society of Mechanical Engineers.

At the 1933 winter convention, the transformer subcommittee submitted a report on impulse voltage testing. The committee is working on a revision of low frequency dielectric tests and is working on recommendations for gap spacings on insulation coordination.

Recommendations for papers for the summer convention were made.

Electrochemistry and Electrometallurgy

At the meeting of the committee on electrochemistry and electrometallurgy, a thorough review was made of papers proposed for future meetings and plans were formulated for a session to be requested in connection with the next winter convention. A number of coordinated papers dealing with electric furnaces as applied to electrochemistry and electrometallurgy were proposed. These will be prepared to cover the

points of views of the manufacturer, the user, and central stations.

It is an aim of this committee to impress upon the Institute membership, the importance of the electrochemical and electrometallurgical industries as one of the largest and fastest growing users of electrical energy, and one which should logically receive far more attention on the part of both the manufacturers of electrical equipment and the power companies.

The meeting was attended by Dr. Colin G. Fink, secretary of the American Electrochemical Society, and many suggestions of value to the committee were received through Dr. Fink's cooperation.

Power Generation

The discussions at the meeting of the committee on power generation covered the plans for the presentation of 3 papers at the 1933 summer convention in Chicago, Ill. The papers that are definitely under way at this time cover a high pressure steam-electric plant that will embody the latest ideas in design, one of the largest hydroelectric plants ever built, and the rehabilitation of a steam-electric plant originally using low pressure steam. The tentative outlines for these papers showed that they will be concerned in the main with economical considerations, with a minimum of description of the special apparatus employed.

Because of the anticipated limitations on convention publications that will be allocated to the committee, it was decided that the symposium on switching and control of power at generating stations should be delayed until the winter convention in January 1934. A very complete outline for 5 or 6 papers on this subject was discussed and approved by the committee. Arrangements have been made for the inclusion in this symposium of a paper on foreign practice.

The discussion of the section on hydroelectric developments in the biennial progress report brought out that there is sufficient material on the subject of pump-storage plants to warrant the preparation of a paper on this subject, and plans were discussed for its presentation.

Another topic that has not been treated in an Institute paper during the last 10 years, but about which an amount of operating experience has developed recently, relates to the locking of electrical apparatus. The sponsorship of a paper on this subject will be undertaken by the committee.

The remainder of the committee's discussion was concerned with the biennial progress report for 1933.

Power Transmission and Distribution

At the meeting of the committee on power transmission and distribution, reports of the activities of the different subcommittees were given, and the proposed programs for power transmission and distribution papers to be presented at the Institute's 1933 conventions to be held in Chicago, Ill., and Salt Lake City, Utah, were considered. Following are summaries of some of the subcommittee reports.

The subcommittee on steel transmission towers and conductors is divided into 3 groups. Group 1, which deals exclusively with towers, is considering hinged and rigid crossarms on towers, embrittlement of steel, comments on the straight line compression formula, and rotated towers (steel towers so placed that 2 legs are on the center line of the transmission lines). Group 2, which is concerned with electrical characteristics of lines and with clearances, is considering a recommended form for service records, clearances as affected by the contingencies of service, and an article to be submitted to Electrical Engineering entitled "Some Important Requirements in Modern Steel Tower Transmission Lines." Group 3, which deals exclusively with conductors, is considering some 23 problems concerned with vibration.

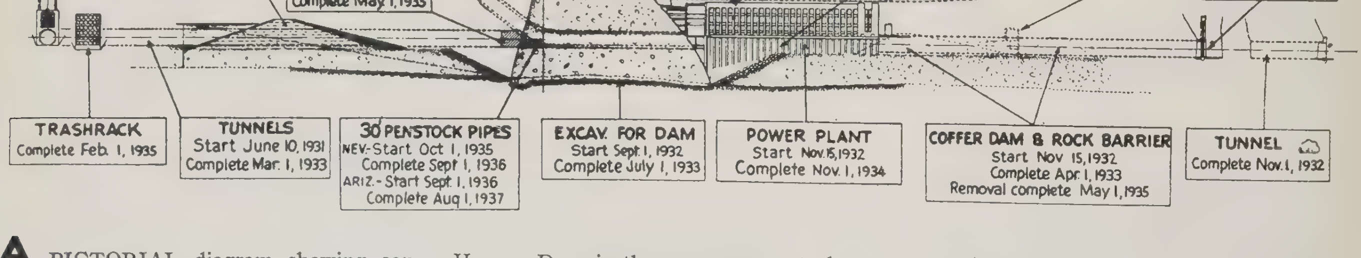
The subcommittee on distribution systems has been concerned principally with scheduling a group of papers by operating engineers on the economics of distribution. Six papers are planned, these are proposed for presentation at the 1934 winter convention. Reports also were received from the subcommittees on underground systems, interconnection and stability factors, and standardization. Attention also was given to definitions on electrical terms, marking of obstructions to air navigation, adequate wiring of buildings, symposium on reactance neutralization in transmission systems, and a résumé of European transmission practice.

A number of subjects was presented by the lightning and insulator subcommittee, including recommended impulse test waves voltage time lag data on insulation, and 60-cycle flashover of suspension insulators. The use of standard impulse waves for testing both lightning arresters and insulators was discussed.

Transportation

At the meeting of the transportation committee it was brought out that the committee had originally requested a session for the Chicago meeting in June, but agreed to withdraw the request in view of the fact

Construction Progress at Hoover Dam



A PICTORIAL diagram showing construction progress of Hoover Dam, power plant, and appurtenant work, is reproduced herewith, from *The Reclamation Era* for February 1933, published by the Department of the Interior, Bureau of Reclamation. Another and separate item of interest in connection with progress at Hoover Dam is the announcement that a loan of $22,800,000 to the municipal power and light system of the city of Los Angeles, Calif., was approved by the Reconstruction Finance Corporation on February 2, 1933, for the construction of a transmission line from Hoover Dam to Los Angeles. A double circuit transmission line having a capacity of 250,000 kw at 275,000 volts is proposed to cover this distance of 271 miles. It is stated that the making of this loan also assures the expenditure of $7,500,000 by the department of light and power of Los Angeles for its share of the cost of the power plant which is now under construction at Hoover Dam.

that no papers on electrification of wide general interest are now on hand and that more sessions have been requested than can be readily accommodated within the limits of time and budget restrictions. It is expected, however, that if any papers of outstanding general interest are submitted within the next 2 months, 1 or 2 papers can be gotten on the program.

The discussion of the committee centered chiefly on the possibilities of outstanding papers for the 1934 winter convention. It was reported that very interesting tests have recently been made on the Pacific Coast on pantograph and contact wire lubrication, and a paper on this subject will probably be offered. It was suggested that one or more additional papers might be secured on pantograph design.

The absent members of the committee are to be canvassed for suggestions for the next winter program.

The question of whether aviation and possibly bus transportation should be included within the scope of the committee's activities also was discussed. It was voted to refer this question to the technical program committee with the suggestion that they secure a ruling.

Sound

At the meeting of the A.I.E.E. committee on sound it was agreed that 2 or 3 papers on noise should be sponsored jointly with the instruments and measurements committee, for presentation at the forthcoming annual summer convention in Chicago, Ill. It is planned to have these papers reveal the latest methods and results of noise measurement in the light of the preliminary standards to be recommended by the American Standards Association. The committee will welcome suggestions from members in connection with this subject.

Preceding the business meeting of the committee on sound, Dr. Harvey Fletcher, Bell Telephone Laboratories, Inc., presented an address on sound measurement that is summarized elsewhere in this issue.

Transformer Subcommittee

At the meeting of the transformer subcommittee of the electrical machinery committee, a number of important matters were discussed. Regarding standardization of flashover voltages for transformer bushings it was the opinion that any standard finally adopted should contain only impulse and wet flashover values since these are the characteristics which are important from an operating standpoint. Consideration is being given to a bushing level 15 per cent higher than the long wave flashover of the coordinating gap, and it is hoped that a single bushing level for all transformers may be established.

In the matter of low frequency dielectric tests, the committee agreed that A.I.E.E. standard No. 13-400 should be modified to increase the low frequency tests in the lower voltage classes to make them consistent with the impulse tests proposed by the subcommittee. The present test would be retained for induction regulators and for dry type apparatus not connected to exposed circuits. It was recommended that paragraph *e* of standard 13-400, and paragraph *n* of standard 13-401 should be revised. These revisions specify the voltage tests of transformers with graded insulation.

It was felt that short time and recurrent overloads cannot be specified in terms of the deterioration of insulation because of the many intangible factors involved, and an alternative basis was suggested employing 3 temperature limits already established in A.I.E.E. standard No. 13. It is believed that a definite recommendation on this subject can be prepared.

The discussion at the Institute sessions relative to the progress report on impulse testing presented during the winter convention was reviewed. It was felt by the committee that methods of detecting damage from impulse tests outlined in the progress report would give reasonable assurance against insulation damage. The reasons for using positive rather than negative waves also were presented. Proper methods of connections for impulse testing and the proper method of correcting for changes in humidity and relative air density were discussed, but no agreement reached.

Corrections and changes in the transformer test code are being considered. Members of the Institute having suggestions to make should send them at once, in quadruplicate, to the chairman of the transformer subcommittee, H. V. Putman, Westinghouse Electric and Manufacturing Company, Sharon, Pa.

Progress in Noise Measurement Standards

Efforts to develop standards for noise measurements were actively initiated during the Institute's North Eastern District meeting held in Rochester, N. Y., April 29–May 2, 1931. As one of the steps in the program to develop standards, a session on sound measurement was held at the recent winter convention, New York, N. Y., January 23–27, 1933. At this session an address was delivered by Dr. Harvey Fletcher (M'23, F'30) of the Bell Telephone Laboratories, Inc. Following this address a meeting of the A.I.E.E. committee on sound was held, as reported elsewhere in this issue. Suggestions from members in connection with the subject of sound measurement will be welcomed by the committee.

A summary of Doctor Fletcher's address, prepared by P. L. Alger, chairman of the A.I.E.E. committee on sound, is presented in the following paragraphs.

Dr. Fletcher described in detail the researches that have been carried on during the last few years in this field, explaining the many difficulties that have been overcome, and the methods followed in arriving at an understanding of the way the human ear registers sound. The most important problems have been the determination of reference levels and audibility ratios for measuring pure notes of different frequencies and means of expressing the total loudness of complex sounds.

Research has shown that the threshold of hearing of a 1,000-cycle tone for the average person occurs at a sound energy level of approximately 10^{-16} watts per sq cm and that this level is of the same order of magnitude as the limit of audibility established by the irregularities of sound due to thermal motion of the air. Thermal agitation of the air acts in much the same way on sound as thermal effects in resistors do on radio transmission, so that in each case there is a definite lower limit to transmission. Careful measurements have been made, determining this threshold of hearing for all audible frequencies, and curves expressing loudness in terms of an equivalent, 1,000-cycle frequency have been established.

It has also been found that the nerves of the human ear which transmit sound to the brain are arranged in a manner similar to that of the keyboard of a piano, giving rise to a masking effect when notes of different frequencies exist simultaneously. Two notes of equal loudness and with frequencies close together give the impression of a much lower intensity than 2 similar notes with frequencies widely separated. This effect cannot as yet be imitated by any noise meter. Dr. Fletcher therefore has developed a system of analyzing a complex sound into its component frequencies, expressing these in terms of a reference note of 1,000 cycles, and combining them by means of frequency masking factors into a single value representing the total loudness.

All of these methods of measurement are being considered by the sectional committee of the American Standards Association established to develop standards in the field of acoustics, and there is reason to expect that this committee will issue at least a preliminary standard on the subject at their next meeting, probably to be held in May 1933.

Plans Under Way for Schenectady Meeting

The meeting of the Institute's North Eastern District, No. 1, will be held in Schenectady, N. Y., May 10–12, 1933. Four technical sessions are scheduled for this meeting in addition to a student session. The technical sessions have been selected to include items of particular interest. There will be a session on air conditioning in industry and the home, a session on aviation, one on reactive power, and a fourth on selected subjects. It will be noted that the first 3 sessions mentioned are subjects of considerable interest at the present time.

Complete details of this District meeting are scheduled for inclusion in the April issue of Electrical Engineering.

Census of Public Utilities

American Engineering Council, in its release of February 1933, reports that the bureau of the census of the United States government, has indicated that the most comprehensive survey of the public utility industry ever undertaken by the government will be made by the department of commerce in connection with its quinquen-

nial census for the year 1932 of the electric light and power, electric railway, telephone, and telegraph enterprises. This census taken every 5 years will provide the first official information since 1927 of the extent of electric transmission, wire and wireless communication, and electric railway transportation, included buses operated in connection with electric railways. Despite reductions in appropriations which will require the gathering of necessary data without the aid of field personnel, the bureau hopes to complete its canvass by July 1, 1933.

Summarized Review of Some Winter Convention Discussions

PRINCIPAL discussions of winter convention papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for January 1933, p. 41–52, and February 1933, p. 122–24, excepting the papers given more complete treatment in these same or previous issues; additional articles based upon these papers are being presented in subsequent issues.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion together with all approved papers will be published in the TRANSACTIONS.

Automatic Stations

PIPE LINE PUMPING AND AUTOMATIC CONTROL

In connection with this subject, M. E. Reagan (East Pittsburgh, Pa.) described a full automatic remotely controlled crude-oil pumping station. One of the interesting features of this installation was the method of indicating the suction and discharge pressures at the control office. Two series of 10 lights each were arranged in a circle with each lamp having a small card-holder adjacent telling the pressure. One series of lamps represented the suction pressure, the other the discharge pressure. With a change in pressure contact-making pressure gages send impulses over the same 2 telephone-size line wires used to control the other equipment changing the lamp indication.

IMPROVED POWER SUPPLY BETTERS STREET RAILWAY SERVICE

A. E. Anderson (Philadelphia, Pa.) discussed this paper and pointed out that the author's 4-years' operating experience with the supervisory control equipment well qualified him to present the principal factors that have to be considered. The discusser drew attention to the improved service and the high degree of availability of the equipment as indicated by the records and the improved voltage which resulted in faster scheduled speeds and improved car lighting.

Electric Welding

HIGH VELOCITY VAPOR STREAM IN THE VACUUM ARC

E. C. Easton and F. B. Lucas (Bethlehem, Pa.) described the apparatus used at Lehigh University to determine the force acting on the electrodes of an iron arc in vacuum and they also presented some of the preliminary test data. Using the same procedure as Tanberg the velocities of the vapor streams were calculated and they were found to come from both anode and cathode. The results of their work lead them to suggest that the current values used by the author and others working with the arc should be increased. The anode forces were almost unobservable at the low current values (30 amp).

NEW STUDIES OF THE ARC DISCHARGE

A. R. Miller in his discussion of this subject cited the author's analogy of the arc phenomena as starting with an equation and its explanation from an energy point of view. He also referred to other theories based upon the assumption of thermionic forces and the influence of the electric field which involve consideration of other mechanism, as for instance the surrounding medium. In his opinion these factors were taken care of in a collective way in the "energy" method of approach. The discusser suggested as another line of attack consideration of the phenomena which occurs in very short-time intervals upon the establishment of the arc or its variation. He believed the cathode ray oscillograph might be useful in verifying some of the ionization theories supposed to play a rôle in arc phenomena.

Communication

COMMUNICATION REQUIREMENTS OF RAILROADS

J. L. Niesse (Detroit, Mich.) explained a misunderstanding that had arisen about a part of this paper. Small auxiliary boards were not generally favored or recommended. However, there were special cases where it might be economical and desirable to install them, for instance, in an outlying yard, where the service is almost entirely local, or cases of very specialized traffic such as the information bureaus, large freight terminals, etc.

In connection with this subject W. H. Arkenburgh (Schnectady, N. Y.) described a system of communication recently developed for freight trains. It can be used to communicate either from front to rear or from a train to a wayside point or from train to train. The rails of the track are connected through impedances to any convenient ungrounded conductor parallel with the track. These impedance couplings consist of 2 condensers in series so arranged as not to shunt the signal track circuit and they are spaced approximately 1,000 ft apart. The equivalent of extremely simple carrier current receiving and transmitting sets are mounted on a locomotive and on the caboose of each train. These sets are connected in each case to inductor coils which are mounted just above the rails at minimum allowable clearance. Automatic volume control is included to compensate for variation and distance between inductor coils and rails due to the action of springs on the rolling stock. Inasmuch as this system does not in any way depend upon space radio propulgation, it can be installed and operated without a license.

H. W. Drake (New York, N. Y.) in his discussion of this subject drew attention to the fact that the telephone, in meeting many requirements of railroad service, sometimes leads to a tendency to ignore situations to which telegraphy is better adapted. In support of the importance of telegraphy he cited the number of telegraph messages made average from 12,000,000 to 36,000,000 per year, as given on page 4 of the paper. Referring to the following paper discussed, he pointed out that the table on page 5 indicated that about 11,000,000 telegraph messages per year were handled on railroad circuits.

COMMUNICATION SYSTEM ON THE PENNSYLVANIA RAILROAD

W. A. Jackson (Detroit, Mich.) in commenting on this paper believed it gave an opportunity to refute the statement so often made that the railroads are not progressive. It would appear they have taken advantage of everything that is available so far as communication service was concerned. With a few more or less minor modifications he believed the communication system described in this paper would apply to most of the other large railroads as well.

SIGNALING, CENTRALIZED TRAFFIC CONTROL, AND TRAIN CONTROL

W. A. Jackson also discussed these subjects and outlined the history of the development of centralized traffic control which began about 20 years ago, soon after the development of the first selector for use on train dispatcher circuits. He believed the centralized traffic control system was first placed in use between Berwick and Stanley Yard, near Toledo, along the Ohio Central Lines of the New York Central in 1927.

J. E. Saunders (Hoboken, N. J.) in his discussion of these subjects mentioned safety as the primary purpose of railway signaling. He pointed out that the secondary purpose, which is that of providing a more economic transportation means, has come rapidly to the front during recent years. As a matter of interest the discusser illustrated to what extent the signal and interlocking practice on a railroad having d-c propulsion different from one utilizing alternating current. This was done by showing the points wherein the Lackawanna Railroad, New Jersey suburban electrification, deviated from the Reading, Philadelphia suburban electrification.

Another discusser, R. M. Phinney (New York) brought out that centralized traffic control was believed by many to be the first major development in the method of operation of trains since the introduction of the train order in 1851. About 900 road miles of this type of control are now in service and it is superseding the train order on a rapidly increasing mileage. He cited its economic advantages, especially during the present business conditions wherein centralized traffic control can handle the traffic with one less track in service. The consequent saving in taxes and maintenance in some cases would amount to $4,000 per main track mile per year. Another item of economy, which was also mentioned, was the consolidation of interlocking plants.

Rotating Electrical Machinery

Low-Frequency Self-Exciting Commutator Generator

F. M. Roberts (Schenectady, N. Y.) analyzed this development from the application standpoint. He cited that it provides a low frequency power supply which can be driven directly from the plant power bus, regardless of the bus voltage or frequency. Previously, machines used for this purpose were of the frequency-changer type, with commutator, and they have usually required a transformer for system voltages over 550 volts. This increased the price of the equipment, decreased the efficiency, and increased the complexity of the installation.

Temperature Rise in Armatures

D. S. Snell (Schenectady, N. Y.) in his discussion of "Some Factors Affecting Temperature Rise in Armatures of Electrical Machines" felt that when it was taken together with a former paper by C. R. Soderberg that the 2 papers served to reduce the complicated heat flow problem to a form readily solvable by the application of Ohm's and Kirchoff's laws. He believed, however, that in seeking a simple solution to this problem the author had reduced the actual thermal circuit of an electrical armature to such a form that the solution could be applied with accuracy to only a limited class of machines. For example, those machines in which the temperature rise of the ventilating air does not constitute an appreciable fraction of the total rises of the copper or iron, and in which the variation of the air temperature along the armature is small. Curves and test data were presented by the discusser to illustrate the point in question.

Another discusser, H. D. Taylor (West Lynn, Mass.) considered the paper with special reference to the interpretation of no-load temperature rise in synchronous machines. He felt there were some complications in the suggested procedure, in that for close results it seemed to be necessary to estimate the temperature rise of the air from the inlet to the middle of the armature teeth for the various test and load conditions; and this involved deducing losses in the core and half the slot depth from total losses. To avoid these complications the discusser outlined a somewhat different method, based, however, on the same principle of superposition which has been applied successfully in turbine generator work at Lynn, and seemed a little easier to use.

Parallel Operation of A-C Generators

W. H. Ingram (New York, N. Y.) discussed this subject and he referred to the work of Routh in his Adams Prize essay at the University of Cambridge for the year 1877. This work considered the stability of the Watt governor and found that its motion was described by a third order differential equation. He found also that the dashpot friction must not be small, so it hardly would be safe to assume that 2 of the roots are conjugate complex. The discusser also cited other references to general criterions of stability.

T. A. Rogers (Berkeley, Cal.) in his discussion of this subject pointed out that an additional oscillating system which might introduce stability problems in governing lies in the mechanical system consisting of the prime-mover, shaft, flywheel, and generator. In some cases the torsional oscillation of this system might coincide with a harmonic of the prime-mover torque, or with the free period of the governor, and might introduce hunting of the prime mover under light load and no load conditions.

Synchronous-Motor Pulling-into-Step Phenomena

I. A. Terry (Schnectady, N. Y.) discussed this paper and he believed that the authors had obtained an analysis of great merit and one which will be of considerable value to the electrical industry as a whole. He pointed out that one of the important features of the paper was showing the benefits which should be obtainable by properly timing the application of field current to the synchronous motor. Test data and curves on 2 synchronous motors which indicated that considerably more benefit was derived from proper timing for large values of relative time constant were presented. The discusser believed that the principal source of difference between calculated and test results was in the authors' assumption that the torque slip curve was a straight line throughout the range of slip during the synchronizing.

Two-Reaction Theory of Synchronous Machines—II

Gabriel Kron (Astoria, L. I.) analyzed the paper explaining that the author had definitely abandoned the old method of attack and struck out along a road with surprising success. Voltages due to leakage fluxes and common fluxes were disregarded while only voltages due to resultant flux linkages were introduced. With this aid the author set up a simple vector equation for the armature which, divided into its scalar components, forms the foundation for all transient and steady state performance calculations, giving in an easy manner rigorous solutions for otherwise difficult problems. The discusser gave a physical interpretation to this equation which extended its application to the rotors of all other asymmetrical machines.

New Floodlights for Madison Square Garden

AN AVERAGE illumination of 72 foot-candles obtained with the new floodlights installed at Madison Square Garden, New York, N. Y., enabled the photograph reproduced here to be taken with only the regular lighting. Illumination 3½ times that obtained in the past is now available in this famous hippodrome which is used not only for hockey games, ice races, bicycle races, boxing and wrestling matches, political orations and horse shows, but also for concerts by Paderewski. The lighting secured with 264 novalux projectors makes it no longer necessary to drop a canopy of high intensity light over the boxing ring, and the disagreeable heat over the arena has disappeared. Motion pictures and "stills" may be taken without flashlamps or spotlights.

Transportation

Application of Air Conditioning to Railroad Passenger Cars

Walter H. Smith (Philadelphia, Pa.) inquired as to which of the 3 types of gears for the generator drive described in the paper—solid, flexible, or slip gear—were recommended for this class of service. He also inquired if the addition of the large generator and its drive to a railway passenger car axle is a liability or an asset to the possibility of flat wheels upon an emergency application of brakes.

Calculation of Single-Phase Series Motor Control Characteristics

Walter H. Smith also discussed this subject and called attention to the high degree of accuracy referred to in the presentation. The discusser's experience had been that such calculations served only to tell what was desired but with so many variables to be encountered in a completed car or locomotive they could never be fully realized. He believed that with the motor engineer, the control engineer, the transformer engineer, and the equipment engineer to satisfy the calculations must be a compromise for the completed car or locomotive for the best all round installation. Therefore the value of the calculations outlined in this paper is that an ideal arrangement can be established when planning such equipment.

Operation of 3000-Volt Locomotives at Cleveland

F. H. Craton (Erie, Pa.) in his discussion of this subject explained that it was still rather early to present a comprehensive picture of operation because estimated future traffic conditions upon which the set-up was based have not as yet been realized except for a very brief period in 1930 and also the maintenance cycle has not yet had a complete rotation. Several features about the locomotive design were discussed as well as the characteristic of the gravity restraint device used for centering the guiding truck bolster. It was also explained that the use of these locomotives with 15-car to 19-car trains over the Cleveland profile required the use of their overload capacity to an unusual extent.

Power Supply for Main Line Railway Contact Systems

D. R. MacLead (Erie, Pa.) discussed this subject and it was his belief that so many economic factors control the layout of a power system for a given electrification that it is almost impossible to cover the subject adequately with a theoretical investigation. Any such investigation is only as accurate as the assumptions permit; however, certain basic principles may be outlined. The discusser felt that the outstanding assumption in the paper was that of fleet movement of trains which were interpreted as implying a very dense traffic movement. He questioned how this assumption would fit a railroad having a varying profile and especially the electrification of a grade. It was assumed that for an actual investigation the authors would lay out the system on the basis of the normal load condition, using certain limiting assumptions for satisfactory normal operation and then check the system for the abnormal conditions which might arise, using the limits specified for satisfactory abnormal operation.

Simplified Speed Control for Single-Phase Locomotives

F. B. Powers and Charles Kerr, Jr. (East Pittsburgh, Pa.) in their discussion of this subject compared the 2 systems of control—one with tap changers, the other with preventive coils. They did not believe Fig. 9 in the paper gave a fair comparison because the locomotive with preventive coils was accelerated at a 30 per cent faster rate, so that the increments would naturally be greater. Secondly, an increment of 15,500 lb is shown with the preventive coil, but with modern designs of preventive coils with suitable air gap increments, as shown by the authors, were not believed to be encountered. They also felt that the weights given in the last paragraph of the paper did not compare favorably with present American practice.

Another discussion by Walter H. Smith (Philadelphia, Pa.) also called attention to the difference in the 2 locomotives *A* and *B* as compared in the paper. In regard to the high voltage tapping switch system of control outlined in Fig. 10, the discusser believed that with the present knowledge of insulating materials, the art had reached a stage where this system has possibilities. He cited that experience in America has shown that a single contactor cannot be relied on to always open the circuit. For this reason a circuit leading to traction motors should be interrupted in at least 2 places when cutting off power. In the opinion of the discusser the parallel connections for all motors, as indicated in the paper, were a great insurance against slipping traction wheels and the resulting damage to motors that might occur.

C. J. Axtell (Erie, Pa.) also commented on the acceleration charts and he pointed out the differences between the 2 locomotives which were compared. He cited reasons for the belief that causes other than the type of control used contributed to the principal influence in setting up the oscillations in tractive effort.

Education

Professional Development of the Engineer

In connection with this subject Paul Cloke (Orono, Maine) believed it would be better to have the degree granting power for the professional degree remain vested in the educational institutions rather than in any group representing the national engineering societies, industries, and the educational institutions, in determining the fitness of any candidate for the degree. The discusser also referred to the proposals being brought forward by educators in the State of Pennsylvania that a complete record of a student's progress through high school be maintained, noting development not only scholastically but morally and physically.

D. C. Jackson (Cambridge A, Mass.) in his discussion of this subject made a plea for support on the part of engineering faculties, as well as the industrialists and practicing engineers, for the new Engineers' Council on Professional Development. The discusser also gave information regarding the constitution of the council and explained that it had a fairly numerous representation of engineering faculties. In conclusion he urged that the new Engineers' Council for Professional Development be given full and adequate support.

C. W. Rice (Montclair, N. J.) discussed this subject and emphasized an idea illustrated by the telephone industry. He referred to the development of the telephone by Professor Bell to help the deaf; he had no commercial motive. The discusser cited that, starting with the conception of the telephone from altruistic motives, by Professor Bell, we have the industry based upon the invention guided in its policies by such men as Mr. Vail and General Carty. One's legal domicile is where he elects to make it. In this same manner one makes his work a profession by his attitude toward it. One is professional to the degree he has a sense of public obligation. The word profession implies an application of special knowledge to the use of others as a vocation, as distinguished from its pursuit for one's own purposes.

Another discussion by Joseph Weil (Gainesville, Fla.) emphasized the importance of a more unified mode of procedure for granting the professional degree of electrical engineer. He explained that at the University of Florida a survey was made of the requirements for this degree and this disclosed a very wide variation in the requirements of different colleges. This University has now materially increased its requirements for the professional degree and now requires a minimum of 5 years of responsible work following graduation, a thesis, and examination. The difficulty in determining the character of responsible work was clearly recognized and it has been conceded that one way in which the applicant can meet this requirement is by securing registration in the State of Florida. In this connection, it might be of interest to note that the national board of engineering examiners has recently proposed a method of accrediting engineering colleges. The discusser asked whether or not the Engineering Council for Professional Development had been consulted in this regard.

Editor's Note: The remainder of these summaries of winter convention discussions is scheduled for inclusion in the April 1933 issue of Electrical Engineering.

Proceedings of Commission on Illumination

The proceedings of the 1931 session of the International Commission on Illumination which was held in Cambridge, England, September 13–19, 1931, have been received in this country. The proceedings are in the form of a cloth bound volume of 694 pages

illustrated with cuts and charts. The resolutions, discussions, and other official material are in French. Some of the secretariat reports are in French and others in German. Nevertheless, there is a slight majority of material in English.

The text is presented in 3 principal sections, the first giving the text of the resolutions passed at Cambridge, the second covering the discussions in the lighting technical committee meetings, and the third containing the secretariat reports and papers which were prepared in advance of the meeting.

Contributions from the United States and other countries published in these proceedings give a picture of the thought and progress in lighting, especially in the United States and Europe. International conclusions in various fields are stated to be of considerable interest, as for example the standards of factory and school lighting, and the coefficients for colorimetry. A table of terms for aviation lighting, with equivalents in French, German, and English is reproduced as under development.

Editor of G. E. Review Retires

John R. Hewett, editor of the *General Electric Review*, Schenectady, N. Y., for nearly 20 years, has retired because of ill health. For more than a year he has been unable to carry on his active duties.

Mr. Hewett was born in England, and received his degree in electrical engineering from Finsbury in 1902. As a special correspondent of the magazine *Engineering* of London, he came to this country to attend the St. Louis Exposition in 1904. After the exposition he went with the General Electric Company at Schenectady in the publicity and transportation departments, and in 1913 was made editor of the *General Electric Review*. During the war he originated a practical submarine-signaling system, and just as the armistice was signed he produced a breach mat that nautical authorities agreed would be effective in saving torpedoed ships. He also was responsible for the development of various other devices.

Doctor Thomson to Be Honored

Plans have been announced for a dinner on March 29, 1933, at which leaders of science, engineering, and industry will honor Dr. Elihu Thomson (A'84, F'13, HM'28, member for life, and past-president) consulting engineer, General Electric Company, and director of the Thomson Research Laboratory at Lynn, Mass. The dinner is to be held upon the occasion of his 80th birthday, at the Massachusetts Institute of Technology, Cambridge, Mass., of which Doctor Thomson was active president from 1920 to 1922, and of which he is now a life member of the corporation.

International in its significance, the dinner will bring together distinguished representatives of the electrical industry to which Dr. Thomson has made so many important contributions, leaders from educational institutions, and officers of the various scientific academies, professional societies, and technical organizations. Preliminary plans for the tribute to Dr. Thomson provide for an afternoon conference on topics significant to the occasion. These include the historical development of the applications of electricity, the recent experimental trends, and latest theories of electricity and matter. In connection with this meeting, plans are being made for an impressive exhibit of many of Dr. Thomson's inventions and contributions in the electrical field.

The committee in charge of arrangements consists of D. C. Jackson, (A'87, F'12), *chairman*, G. C. Dahl (A'22, M'25), *secretary*, and C. G. Abbott, James R. Angell, W. W. Campbell, H. P. Charlesworth (M'22, F'28, president), Karl T. Compton (F'31), H. W. Cushing, N. J. Darling, Alexander Dow (A'93, F'13), Paul D. Foote, W. C. Forbes, J. D. M. Ford, T. S. Gates, G. E. Hale, Nathan Hayward (A'05, M'12), Frank B. Jewett (A'03, F'12, past-president), A. E. Kennelly (A'88, F'13; past-president), J. C. Lincoln (A'07, F'32), A. D. Little, A. Lawrence Lowell, Roland S. Morris, C. W. Rice (A'97, F'12, member for life), E. W. Rice, Jr. (A'87, F'13, past-president), A. W. Robertson (A'27), A. L. Rohrer (A'87, M'88), C. H. Sharp, (A'02, F'12), Ambrose Swasey (HM'28), Gerard Swope (A'99, F'22), and E. S. Webster (A'91, M'07).

ELIHU THOMSON

Weather Resistant Coverings for Line Wires

Throughout the past $2^1/_2$ years investigations have been carried on by the electrical and chemical divisions of the Engineering Experiment Station at Purdue University, Lafayette, Ind., in cooperation with the Utilities Research Commission of Chicago, Ill., leading to the development of improved weather resistant coverings for overhead electric light and power wires, and in perfecting accelerated weathering and other tests for determining the comparative merits of such coverings. These investigations are described and summarized in a bulletin entitled "Improved Weather Resistant Coverings for Overhead Line Wires" by L. L. Carter (A'29), J. W. Olson, C. F. Harding (A'06, F'14), and R. N. Shreve; the bulletin, No. 43, may be obtained from the Engineering Experiment Station, Purdue University, Lafayette, Ind., free to residents of Indiana, and at a cost of 50 cents to non-residents.

In this bulletin a brief comment is made upon the changes in methods of producing weatherproof wire, the forces that have been at work to lower the quality of the coverings on such wires, and the economic justification for improved coverings, even at a slightly higher first cost. The equipment developed and constructed and the test methods utilized in this work are described. The reasons for the variable life, often very short life of weather resistant coverings, together with illustrations showing test results, are summarized. The development work leading to the final selection of a class of asphaltic saturating materials providing consistently long-lived coverings is traced. Chemical analyses of asphalts are described and the lack of correlations with weather resistance shown. Finishing materials and possible future improvements in weather resistant coverings are discussed. The specifications, proved by this work to provide improved weather resistant coverings, are given in detail, as are also the details of the accelerated weathering test which has been developed to a point of extreme usefulness in testing weather resistant wire coverings.

The conclusions, specifications, and tests resulting from the work described in this bulletin should prove of aid to both the manufacturer and the purchaser of weatherproof wire, in increasing the length of life of overhead electric light and power wires, and in reducing the expenditure for replacement of wires still capable of rendering adequate electric service except for the shedding of the coverings.

The principal results and conclusions drawn from these investigations were presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932. This material was published in Electrical Engineering for May 1932, p. 299–304, with additions and revisions which brought it up to that date. Engineering Experiment Station Bulletin No. 43, contains this information with numerous additions and details of methods used.

40,000-hp Motors for New French Ship.—The new French superliner "Normandie" which was launched October 29, 1932, will be propelled by 4 motors which it is stated are the largest ever built for any purpose. These motors are rated at 40,000 hp each, giving the new ship a total rating of 160,000 hp. The 4 synchronous propulsion motors and auxiliary electrical equipment for the "Normandie" were built by Als-Thom, French associate of the General Electric Company. In spite of the large size of these motors, however, it is stated that the 2 airplane carriers, U.S.S. "Saratoga" and U.S.S. "Lexington" will still rank as the world's most powerful ships as they are each propelled by 8 motors rated at 22,500 hp apiece, giving a total of 180,000 hp per ship. These airplane carriers have 4 shafts with 2 driving motors on each propelling shaft.

Rail Motor Cars Operated Economically

Gas-electric rail motor cars operated on the Southern Pacific Lines in Texas and Louisiana show substantial savings in operating costs over comparable steam train service. During 1929 and 1930 a total of 12 cars were placed in service, 8 of them being equipped by the General Electric Company. Six cars, purchased in 1930, are each equipped with a 400-hp engine, while the others each have a 300-hp engine. These cars, together with trailers, replaced steam trains on a number of lines. The condensed operating results are shown in Table I.

Table I—Operation of Gas-Electric Motor Cars

	1929	1930	1931
Number of gas-elec. motor cars	4	12	12
Motor train miles per motor car per day	248	257	257
Total motor train mileage	234,370	989,498	1,060,742
Total trailer mileage	236,523	1,268,211	1,242,336
Availability of motor cars	92.1%	95.3%	96.2%
Repair cost for motor equipment per motor train mile	$0.034	$0.031	$0.038
Operating cost per motor train mile, including depreciation and interest at 6% (Trailers included)	$0.375	$0.3896	$0.3719
Annual saving over comparable steam train service	$77,225	$307,140	$348,029
Total motor car investment	$195,796	$631,038	$631,038
Net saving in % of investment	39.4%	48.7%	55.2%

In addition to the modern cars covered in Table I, the Southern Pacific Company is operating in this same district 2 of the older type gas-electric cars built in 1912. These have been in almost continuous service since their installation. It is reported that during 1931 these cars were operated 114,715 motor train miles with 114,651 trailer miles, had an availability of 95.9 per cent, a repair cost for motor equipment per mile of $0.037, and at an operating cost of cars and trailers including depreciation and interest of $0.4441 per mile.

Officers Elected for Chemical Society

Following a meeting of the council of the American Chemical Society, it was announced that Dr. C. L. Reese has been elected president of the Society for 1934. Doctor Reese retired in 1931 as chemical director of E. I. du Pont de Nemours & Company, Inc., Wilmington, Del., after having served that company in various capacities since 1902. He has been a director of the corporation. He also has been president of the American Institute Chemical Engineers and of the Manufacturing Chemists Association, an associate member of the Naval Consulting Board, a member of the board of trustees of International Critical Tables, and has served as an officer of 2 divisions of the National Research Council.

Prof. A. B. Lamb of Harvard University, Cambridge, Mass., became president of the Society on January 1, 1933, and serves throughout this year. District directors elected for 1933 are Prof. J. F. Norris, Massachusetts Institute of Technology; Dean F. C. Whitmore, Pennsylvania State College; and Dr. M. C. Whitaker, American Cyanamid Company, New York, N. Y. Councilors-at-large chosen include: Prof. B. Conant, Harvard University; Dr. John Johnston, U.S. Steel Corporation, Kearny, N. J.; Prof. C. A. Kraus, Brown University; Dr. David Wesson, consulting chemical engineer, Montclair, N. J.

American Engineers War Memorial Carillon

On July 4, 1928, a carillon was presented by the members and friends of the principal engineering societies of the United States in memory of the engineers of this country who gave their lives in the service of their country and its allies in the great war, 1914–18. This carillon is installed in the Bibliotheque de L'Universite, Place du Peuple, Louvain, Belgium.

In the annual report on the condition and use of the carillon, presented at the end of the academic year 1932, E. Van Cauwenbergh, chairman of the memorial carillon committee and librarian of the Bibliotheque de L'Universite, states that the carillon is very much appreciated and frequently used. Carillonneurs from all parts of the world visit Louvain for the purpose of using its clavier.

Propose Rating of Buildings for Investors

The board of direction of the Western Society of Engineers at its August 1932 meeting authorized the appointment of a special committee to study the services of engineers in safeguarding investments offered to the public. That committee, consisting of C. B. Burdick, *chairman*, F. D. Chase, H. H. Hadsall, W. O. Kurtz, Edgar Martin, and C. L. Post, has drawn up the following resolution, which was approved by the Board at its last meeting:

"Whereas, Investments in buildings have been and will be a favored form of investment in original construction and in mortgage on structures already built; and

"Whereas, The public has suffered enormous losses in recent years due to irresponsible promotion, inflated valuation, and because of improper designs, faulty and fraudulent construction and incompetent inspection, and

"Whereas, The investing public should demand and be able at all times to obtain accurate, complete, and trustworthy information concerning the physical condition and value of property in which it is invited to invest, therefore,

"*Be It Resolved*, That the Western Society of Engineers recommends:

"1. That competent technical specialists should be employed to supervise the design and the construction of all projects offered for investments, and the examination of old structures before mortgage issues.

"2. That all such investment projects new or old should be classified as to structural safety, efficiency of operation, and economy of maintenance, and

"3. That the investing public be furnished, in connection with each project hereafter offered for investment, a 'Certificate of Rating' determining the physical condition of the property, based upon accurate, complete, and trustworthy examination and classification by qualified experts, and

"*Resolved*, That the Western Society of Engineers cooperate with other interested organizations and officials, including the State Insurance Departments and organizations of lenders; such as insurance companies, banks, trust companies, building and loan societies, and investment corporations, in promoting the general adoption of the preceding resolution and in the development of adequate Standard Specifications for Classifying Buildings and other projects, and,

"*Resolved*, That such further steps be taken as may be expedient to combat effectively the investors and mortgage lenders who disregard competent engineering counsel and services in new construction and in alteration of buildings."

Conference on Economics of Applied Lighting

Good lighting expressed in dollars and cents was the keynote of a 2-day conference recently held by the Case School of Applied Science, Cleveland, Ohio, February 8–9, 1933. Foremost among the many subjects discussed were: seeing and its practical applications, the cost and value to the consumer of adequate wiring and proper voltage maintenance, the evaluation of accident costs and industrial savings as effected by proper lighting, and lighting and production economics. In addition to these topics, other subjects of value to the managerial and electrical groups were covered.

The speakers included L. W. W. Morrow (A'13, F'25), Ward Harrison, J. W. Barker (M'26, F'30), and S. G. Hibben. H. B. Dates (A'98, M'13) was general chairman. Copies of all the addresses given at the conference may be secured by addressing the publicity department, Case School of Applied Science, Cleveland, Ohio. Complete sets of the 13 papers will be mailed for $2.

Home Study Course in Air Conditioning.—Rutgers University has announced a new and modern home study course in air conditioning. The course is in 12 sections, and encompasses the major principles of the scientific preparation and treatment of air in large and small systems. Further information may be obtained from the University Extension Division, Rutgers University, New Brunswick, N. J.

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely.

STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

Research Proposed for Emergency Relief

To the Editor:

There are being advanced countless suggestions pertaining to alleviating the results of the present depression, many of which come from the unemployed who are particularly able at this time to make such suggestions since they have the time to give the matter serious thought. I wish to offer here another plan designed to give the greatest return to the organization having the courage to sponsor it and at the same time give worthy and inspiring employment to thousands of young engineers and scientists who are idle through force of circumstances.

Our great utilities and industrial organizations ordinarily spend large sums for research from which they see immediate and long-time returns, financial and otherwise. Naturally, during depressions, this type of expenditure must be reduced as being a luxury and least necessary to the industry. This procedure is justified only from the standpoint of immediate financial stability and our wisest executives realize that in curtailing their research activities, progress in their field, so essential to them, is materially hampered. Such curtailment is as unnecessary as it is harmful; research activity can be economically expanded rather than be reduced.

In every one of our larger cities there are hundreds of young engineering graduates unemployed, among whom are many of exceptional ability. There are many single men who have the good fortune of being able to live economically with their parents and who on a small salary could at least be self supporting. Give them a job in which they could be deeply interested at a consolation wage of $8 to $10 a week by expanding our research laboratories to an extent which each company could individually determine! There are thousands of projects which require investigation; every wide awake man in charge of a research department knows of number of them which he has always wanted to tackle but lacked the facilities and men to carry through.

Here is the chance—thousands of trained men are ready to seize the opportunity to engage in this type of work at a nominal wage, because it is the one type which they feel develops their own ability and gives them a training far superior to their university training. Many of them would welcome the opportunity, if financially able, to return to study for higher degrees, and now comes this chance to do something worthwhile and still be able to just tide them over the depression years without being a financial burden upon their relatives.

Those companies having research departments already in operation could launch such a project within a week's time. Individual and governmental support could also be given to this plan. The municipal welfare departments help the unskilled laborer with dependents by giving him manual labor of a menial character. Little is done for the young unemployed skilled engineer. Give him a job of this kind, one that would make him proud to say that he is employed in the research department of "so and so" company. Can we do something about this?

Very truly yours,
MARTIN E. BERMAN (A'29)
(3784 Wagner Ave., Detroit, Mich.)

Engineering and Human Happiness

To the Editor:

In discussing the effect of engineering progress on the happiness of the human race, many people seem to have forgotten that the golden age of Greece was largely supported by slave labor. Engineering progress has supplied an ever more capable collection of mechanical slaves. Certainly the application of these slaves to bring about a new golden era should not be discouraged merely because society so far has failed to make a proper distribution of this slave labor.

Very truly yours
D. C. PRINCE (A'16, F'26)
(Engineer, switchgear dept., General Elec. Co., Phila., Pa.)

All Classes of Individuals Are Responsible for Conditions

To the Editor:

Referring to the article "Usury on Labor," by Robertson Matthews, appearing on p. 866 of the December 1932 issue of ELECTRICAL ENGINEERING, the first sentence of the last paragraph reads: "With such pay, employees *could* better meet fluctuations in employment . . . ." After thinking of the various get-rich-quick schemes of the last quarter of a century or more, in which persons of all degrees of servitude and all grades of mentality have participated with abandon, I wonder what reason we have to think that they *would* do so. Is any one class less grasping than another when it has opportunity? Are not the individuals in the world the chief cause of the trouble in the world? Is not the primary remedy to stop class talk and examine individuals, and after proper consideration apply remedies that will benefit both the chastened individual and the rest of the world, although when necessary putting the good of the many before the good of a wrong doer?

I have been a laborer, of one kind or another, since I was 13.

Very truly Yours,
H. H. KETCHAM (A'13, M'23, Life Member)
(26-G Breese Terrace, Madison, Wis.)

Paralleling Rotor and Stator

To the Editor:

I was requested by Mr. W. A. Tolwinsky, professor of electrical engineering, Polytechnical Institute, Leningrad, U. S. S. R. to forward to ELECTRICAL ENGINEERING his discussion of the paper "An Induction Motor with Paralleled Rotor and Stator." That paper was presented before the winter convention of the A.I.E.E. Jan. 25–29, 1932, by Messrs. A. G. Conrad and R. G. Warner, and was published in the A.I.E.E. TRANS., v. 51, 1932, p. 418–22.

I trust that it will be possible to print Professor Tolwinsky's discussion, which is quoted herewith:

"With this paper of Messrs. Conrad and Warner I am acquainted only from the article 'Paralleling Rotor and Stator' printed in ELECTRICAL ENGINEERING, March 1932, p. 171–3. The authors discuss this question as a new problem and make a very optimistic conclusion regarding the performance of this motor. In fact, both opinions are erroneous. As far as I know, this problem was originally discussed in my article published in the Russian journal *Elektrichestvo* in 1923. (See reference 1.)

"Later on, my assistant, S. M. Hochberg, continued the investigation and published the results in the same journal in 1926. (See reference 2.) As *Elektrichestvo* at that time was very little known abroad, the results of both the papers were also printed in the well-known German journal *Archiv für Elektrotechnik*. (See reference 3.)

"Referring to the matter itself we must at first point out that the starting of the induction motor with paralleled stator and rotor may be accomplished much simpler

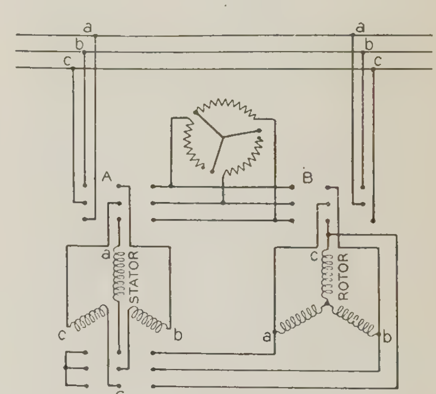


Fig. 1

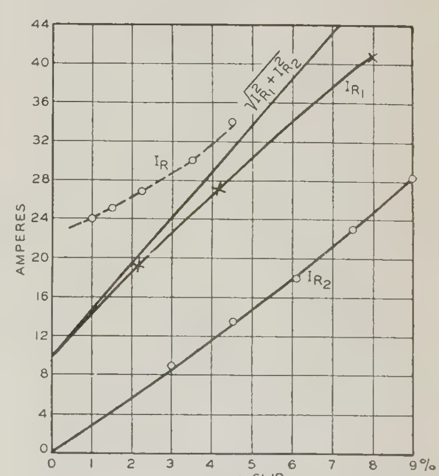


Fig. 2

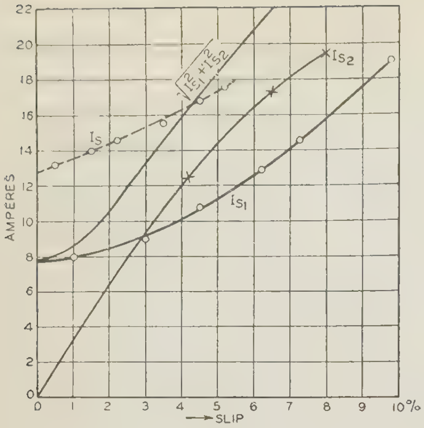


Fig. 3

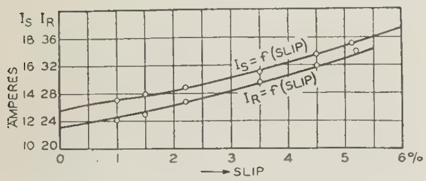


Fig. 4

than this was done by Messrs. Conrad and Warner. The connection which was used by me for this purpose is shown in Fig. 1. With the switches A, B, and C closed on their left hand position, one obtains the normal starting of a slipring motor with the rotor acting as a secondary winding. In this case, if the stator field (observed from the side of the sliprings) rotates clockwise, the motor will rotate in the same direction. Let the switches A and B be changed over to the right hand position, then the motor begins to operate, having the rotor as a primary and stator as a secondary. To obtain the same direction of rotation as in the first case, the connections of the rotor winding must be made in such a manner as to cause the rotor field to rotate counterclockwise relative to the rotor body. If this is done the motor starting can be made as follows: Close the switches A, B, and C on their left throw and when the normal speed of the motor is reached, throw the switch B over to the right side; the starting is then finished. At this double supply the machine can be treated as a combination in one unit of 2 separate normal induction motors of which one, designated in the following as A_{SR}, has the stator as a primary, and the rotor as a secondary connected to 2 paralleled impedances: Z_n, the impedance of the supplying network; and Z_s, the same of the stator winding. The other motor, designated as A_{RS}, has the rotor acting as a primary and the stator as a secondary, which is connected to 2 paralleled impedances: Z_n, as above; and Z_R, rotor winding impedance. It is obvious that in case of a full identity of the stator and rotor windings ($Z_s = Z_R$), the physical phenomena in them must be the same, and each of the motors A_{SR} and A_{RS} must carry $1/2$ of the total load. The current of each motor winding consists of 2 components: I_1, primary current of the network frequency F; and I_2, secondary current having a frequency $F_s = F_S$, where S is the slip. Therefore, the stator and rotor currents can be expressed by the following formula:

$$I_s = I_R = \sqrt{I_1^2 + I_2^2} \qquad (1)$$

"When the motor is loaded, the primary current of the motors A_{SR} and A_{RS} is greater than that of the secondary, on account of the exciting component. Neglecting this difference, let us assume $I_2 \approx I_1$. therefore, we can write:

$$I_s = I_R = \sqrt{2I_1^2} = I_1\sqrt{2}$$

whence

$$I_1 = \frac{I_s}{\sqrt{2}} = \frac{I_R}{\sqrt{2}} = \frac{I_N}{\sqrt{2}} = 0.707\ I_N$$

where I_N is the rated current of the motor.

"The summary current of frequency f feeding the double supply motor from the network must be, therefore, no greater than:

$$I = 2 \times 0.707 \times I_N = 1.41 \times I_N$$

"Taking into account the really existing inequality $I_2 < I_1$, we can assume the rating of the double-supply motor to be approximately equal to 1.5 of its normal rating.

"These conclusions are correct only with the assumptions that the network impedance $Z_n = 0$, and the magnetic circuit of the motor is far from saturation. If $Z_n \neq 0$, we shall have an increase of secondary reactance and resistance; the first factor decreases the breakdown torque, while the second factor increases the slip and consequently diminishes the efficiency of the motor.

"In order to prove the influence of the saturation of the magnetic circuit, a series of tests were made in the laboratory of the Leningrad Polytechnical Institute. The tested machine was a slipring induction motor of Garbe-Lamayer Werke, rated 7.5 hp, 50 cycles, 3 phase, 230 volts, 960 rpm. As the ratio of stator to rotor turns was far from one, the rotor was connected to the line voltage through a transformer. As the latter also had not sufficient voltage ratio, the load could not be divided evenly between the motors A_{SR} and A_{RS}. It is obvious that in such a case the stator and rotor currents may be calculated separately.

$$I_s = \sqrt{I_s^2 + I_{s2}^2};\ I_R = \sqrt{I_{R1}^2 + I_{R2}^2} \qquad (2)$$

where

I_{s1} and I_{s2} = primary and secondary currents in stator winding, i. e., primary current of the motor A_{SR} and the secondary current of the motor A_{RS}

I_{R1} and I_{R2} = primary and secondary currents in rotor winding, i. e., primary current of the motor A_{RS} and the secondary current of the motor A_{SR}.

"The results are shown in Figs. 2 and 3; a comparison of the dotted curves I_s and I_R received from tests with the calculated curves, plotted by solid lines shows a very appreciable difference in magnitude. This indicates that the assumed superposition of the operations of the 2 independent motors A_{SR} and A_{RS} is not quite correct for the normal machines on account of the saturation of the iron. A full coincidence of the test and calculated values of the stator and rotor currents may be obtained through the use of the circle diagram of the motors A_{SR} and A_{RS}, based upon the following test data of these motors: normal short-circuit tests and running idle tests at the double supply. In Fig. 4 is shown the results of such an investigation made upon the machine mentioned above. The plotted curves are calculated, the points are received from tests.

"An interesting theoretical problem is the calculation of the exciting current of a normal slipring induction motor, connected to a double power supply. This probem was solved by S. M. Hochberg. (See reference 4.)

"A disagreeable feature of the asynchronous double-supply motor is the influence of the secondary currents on the line voltage. The investigation of this problem can be made using the curve presented in Fig. 5. This curve, published by Prof. H. A. Lust in the year 1912 (see reference 11) shows the greatest amplitude of the alternating emf as function of its frequency, which emf can be superposed upon the constant emf feeding the incandescent lamps without producing any light flicker, noticeable to the eye.

"In Fig. 6 the admissable ratio Z_n/Z is shown as function of motor slip, where Z_n is the impedance of the supplying network, and Z is the impedance of the stator or rotor winding. We see that the results are not very favorable for the commercial use of the asynchronous double supply motor.

"In another way it might be pointed out that this motor has not only a theoretical interest, as some time ago it received practical application in 2 cases. The first application, made by Eliashevitch (reference 5) and independently by Bamdas (references 6, 7), is for artificial loading of normal induction motors. The second one proposed by Aparov (reference 8), was intended for the purpose of diminishing the starting current of induction motors."

References

"1. The 3-Phase Induction Motor at Double Supply, W. A. Tolwinsky. *Elektrichestvo*, 1923, No. 5/6, p. 274 (Russian).

"2. Asynchronous Operation of 3-Phase Induction Machine Doubly Connected to One Network, S. M. Hochberg. *Elektrichestvo*, 1926, No. 9, p. 390 (Russian).

"3. Asynchrone Betriebsweisen der Drehstrom-Induktionsmaschine bei doppelter Speisung von ein und demselben Netz, W. A. Tolwinsky and S. M. Hochberg. *Archiv für Elektrotechnik*, v. 20, 1928, No. 5, p. 162.

"4. Der Magnetisierungsstrom eines asynchronen Drehstrommotors, welcher ein Wechseldrehfeld besitzt, S. M. Hochberg. *Archiv für Elektrotechnik*, v. 22, 1929, No. 2, p. 187.

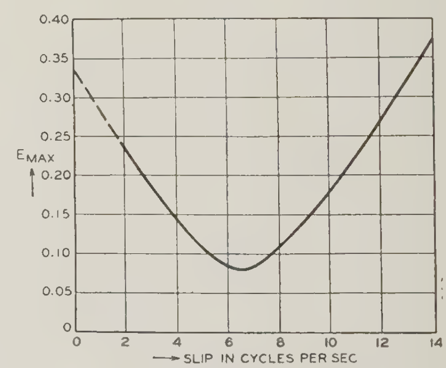


Fig. 5

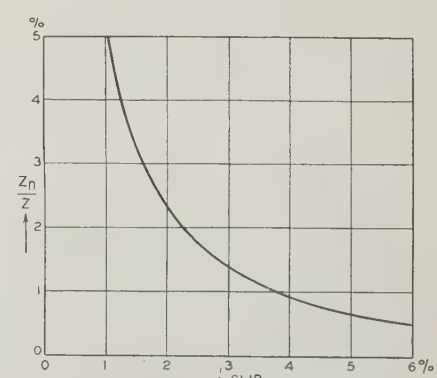


Fig. 6

"5. A New Method of Artificial Loading of 3-Phase Induction Motors, S. B. Eliashevitch. *Trans. Baku Polytechnical Inst.*, 1928 (Russian).

"6. A New Method of Heating Tests of Induction Motors, A. M. Bamdas. *Annals State Elec. Trust*, 1929, No. 2/3, p. 46 (Russian).

"7. Eine Methode zur kunstlichen Belastung von Induktionsmotoren, A. M. Bamdas. *Elektrotechnik und Maschinenbau*, 1931, No. 5.

"8. Asynchronous Double Supply Motor With Auxiliary Stator Winding, B. P. Aparov. *Herald of Theoretical and Experimental Elec. Engg.*, 1931, p. 32 (Russian).

"9. Asynchronous Frequency Converter, A. M. Bamdas. *Elektrichestvo*, 1928, No. 23/24, p. 505 (Russian).

"10. Asynchronous Operation of Cascade Connections, A. M. Bamdas. *Herald of Theoretical and Experimental Elec. Engg.*, 1930, p. 26.

"11. Sur L'Utilisation Des Moteurs Diesel Dan Les Usines Electriques, H. Lust. *Annales De L'Institut Polytechnique A St. Petersburg*, t 18, p. 197, 1912, (Russian)."

Two reprints from the *Archiv für Electrotechnik*, with the articles to which Professor Tolwinsky refers, are also attached.

Very truly yours,
L. A. Umansky (A'16, M'27)
(General Electric Co., Schenectady, N. Y.)

Standards

Abbreviations for Scientific and Engineering Terms

The standards committee of the Institute wishes to call particular attention to the availability of a pamphlet entitled "Abbreviations for Scientific and Engineering Terms." These abbreviations, which were approved as "tentative American standard" on November 17, 1932, were developed by the sectional committee on scientific and engineering symbols and abbreviations working under the sponsorship of 3 national engineering societies in the civil, mechanical, and electrical fields, together with the American Association for the Advancement of Science, and the Society for the Promotion of Engineering Education. Every effort is now being made by the American Standards Association to obtain the use of these abbreviations nationally, and an appeal has been made to the public printer at Washington, D. C., to adopt them in all government work. The pamphlet may be obtained through the American Standards Association, 29 West 39th Street, New York, N. Y. The cost is 40 cents per copy.

Measurement of Test Voltages in Dielectric Tests

By action of the Institute's board of directors on October 12, 1932, a revision of the standard for "Measurement of Test Voltages in Dielectric Tests" was approved. While notice to this effect was published in the November 1932 issue of Electrical Engineering, p. 815, the standards committee feels that this change may have been overlooked and suggests that the revised paragraph following be slipped out and inserted in the A.I.E.E. Standards No. 4 to replace the first 6 lines of paragraph 102, "Impedance of Testing Transformers. For accurate tests, the impedance of the testing transformer should be not greater than 20 per cent based on voltage and current at which the transformer is operated for any test."

Wires and Cables

The sectional committee on insulated wires and cables will continue its work in the future under a revised plan of organization. In place of the 9 controlling sponsors, the electrical standards committee now holds the sole sponsorship. New officers have been elected as follows: F. M. Farmer, *chairman;* G. M. Haskell, *vice-chairman;* W. F. Davidson, *secretary.*

Development of a Ventilation Code Proposed

At the standards committee meeting of January 23, 1933, an invitation was received from the American Standards Association calling for participation by the A.I.E.E. in the development of a ventilation code. The scope of the work, which will be undertaken, is as follows: "Safety standards for the construction and operation of mechanisms and devices for such conditioning and renewal of air as to tend to render it fit for human respiration. Incidental to the main object, such ventilation will remove dust, fumes, and gases. Applicable in tunnels, subways, factories, schools, places of public assembly, and other enclosed spaces in which men live or work." This work will be carried on by a representative sectional committee and under the sponsorship of the American Society of Heating and Ventilating Engineers. The invitation was accepted and a representative and alternate will be appointed.

Transformers

The organization of a sectional committee on transformers is now under way. This sectional committee is one of a series of committees proposed to cover the main divisions into which the electrical apparatus field can be divided. For instance, the committee on rotating electrical machinery has been under way for some time, as has that on insulators, while others about to begin work are power switchgear, electrical measuring instruments, etc. All these will be under the sponsorship of the electrical standards committee. The A.I.E.E. standards committee voted to approve the appointment of 4 A.I.E.E. representatives on the transformer committee. The basis of the committee's work for the present will be A.I.E.E. Standards Nos. 12, 13, 14, and 100. The committee's scope will be as follows: "Formulation of standards for transformers (exclusive of autotransformers used as part of auto starters, automotive ignition transformers, and communication transformers); voltage regulators of the induction or transformer type; and reactors."

As a matter of interest, attention is called to the committee reports appearing elsewhere in the news section of this issue listing proposed developments and revisions of the A.I.E.E. Standard No. 13 on "Transformers, Induction Regulators, and Reactors." This work is being carried on by the subcommittee on transformers of the electrical machinery committee.

Electrical Measuring Instruments

An invitation to appoint representatives on a sectional committee on electrical measuring instruments similar to that covered in the preceding item on transformers was approved by the Institute's standards committee on January 23, 1933. This committee, under the sponsorship of the electrical standards committee will have the following scope: "Definitions, classification, rating, methods of test, and construction details for all types of electrical measuring instruments but not including (1) watthour meters, (2) demand devices and their auxiliary apparatus, and (3) low precision or special instruments." The basis of the committee's work will be A.I.E.E. Standard No. 33.

Revision of Welding Standards Approved

On January 23, 1933, the standards committee approved a report of the sectional committee on electric welding apparatus. This report covers a revision of the present A.I.E.E. welding standards Nos. 38 and 39, "Electric Arc Welding Apparatus" and "Resistance Welding Apparatus." The sectional committee having this work in charge is under the joint sponsorship of the A.I.E.E. and the National Electric Manufacturers Association and the chairmanship of F. M. Farmer. The board of directors of the Institute on January 25, 1933, confirmed the action of the standards committee and the 2 revised standards will now come before the American Standards Association for approval as American standard. Following action by the A.S.A. they will be made available in pamphlet form.

Inch-Millimeter Conversion Factor Revised

At a general industrial conference held under the auspices of the American Standards Association on October 21, 1932, unanimous approval was given to a suggested conversion factor for the inch-millimeter of 25.4. This displaces the former factor of 25.40005. At the conference it was pointed out that the error involved in adopting 25.4 was so small that it could be left out of consideration in view of the fact that uncontrollable errors of equal or greater magnitude creep into calculations and also because of tolerances permitted in most industrial work. The board of directors officially confirmed the acceptance of 25.4 factor at their meeting of January 25, 1933.

School Lighting Standards

Attention is called to the availability of a pamphlet entitled "Standards for School Lighting." These standards constitute a revision of the "Code of Lighting School Buildings" adopted in 1924 as an American standard. In this new edition, approved as American standard on September 15, 1932, emphasis has been placed on recommended practice instead of minimum requirements. Its primary purpose is to establish criterions of good illumination for the guidance of architects, engineers, school officials, and others interested in the conservation of the children's vision and the efficiency of children and teachers. Work on the code was carried on under the sponsorship of the Illuminating Engineering Society and the A.I.E.E. Copies of the code may be obtained through the headquarters of the I.E.S., 29 West 39th Street, New York, N. Y., at a cost of 20 cents each.

Standardization of Names for Electronic Devices Proposed

At the meeting of the Institute's standards committee of January 23, 1933, a suggestion was received that a committee be appointed to consider the adoption of appropriate names, free of trade-mark restrictions, to designate the many electronic devices now coming into use. The fields of devices, such as the General Electric "thyratron," the corresponding Westinghouse "grid-glow," and other similar tubes are rapidly developing, and the clarity of descriptive literature is suffering from the lack of a standardized terminology. By action of the standards committee a special committee was authorized to survey this matter. (See "Hot Cathode Electronic Tube Designations" appearing on p. 170 of this issue, for a table of some of the designations involved.)

Engineering Foundation

Election Held by Engineering Foundation

At its annual meeting February 16, 1933, The Engineering Foundation's board reelected as its chairman George W. Fuller, consulting engineer, former vice-president of the American Society of Civil Engineers, New York, N. Y., and a member of the firm of Fuller and McClintock. H. P. Charlesworth (M'22, F'28 and president) vice-president of Bell Telephone Laboratories, Inc., New York, N. Y., was elected first vice-chairman. Second vice-chairman is H. C. Bellinger. These members, together with D. Robert Yarnall and J. V. N. Dorr, constitute the executive committee. Dr. A. D. Flinn continues as secretary and director.

New members elected to The Engineering Foundation's board whose terms began at the annual meeting on February 16, 1933, are as follows: Arthur S. Tuttle, J. V. N. Dorr, and Harold V. Coes, ex-officio, president United Engineering Trustees, Inc. Members of the board reelected for terms beginning February 16, 1933, are: George W. Fuller, Otis E. Hovey, Albert E. Smith, C. E. Skinner (A'99, F'12, and junior past-president) and H. Hobart Porter (A'96, M'12, and life member). These 8 new and reelected members were elected for terms of 3 years expiring at the annual meeting in February 1936, or upon expiration of their terms as trustees of United Engineering Trustees, Inc. Holdover members of The Engineering Foundation's board are: George D. Barron, Edwards R. Fish, H. P. Charlesworth, H. C. Bellinger, E. de Golyer, D. Robert Yarnall, George D. Crawford, and W. I. Slichter (A'00, F'12, national treasurer and past vice-president). The Institute's representatives on this board are Dr. C. E. Skinner and Prof. W. I. Slichter.

An outline of the organization and objects of The Engineering Foundation is given in a companion article in this issue.

Annual Report Issued by Engineering Foundation

The annual report of The Engineering Foundation was recently made public by H. Hobart Porter (A'96, M'12, and life member) chairman for 1932 of The Engineering Foundation and president of the American Waterworks and Electric Company, Inc., New York, N. Y. It is stated that despite difficulties of current business conditions, 1932 was a year of encouraging progress and achievements by The Engineering Foundation, which is the research organization of the 4 national societies of civil, mining and metallurgical, mechanical, and electrical engineers. A brief outline of the organization and objects of The Engineering Foundation is contained in a companion article in this issue. Following are excerpts from the Foundation's annual report.

"Arch dams for water supply, power development, flood control and irrigation, and steel columns for buildings and bridges were the subjects of 2 researches completed. The iron alloys committee published 'The Alloys of Iron and Molybdenum,' the first book in its series on the combinations of iron and steel with other substances. A guidance pamphlet, 'Engineering: a Career—a Culture,' which is being well received, resulted from the efforts of the educational research committee.

"Subjects of other researches aided by the Foundation, and progressing in many parts of the country, include concrete arches for bridges; earths and foundations; centrifugal apparatus for testing mining excavation methods, models of structures and specimens of materials; boiler feedwaters; critical pressure steam boiler; effects of temperature on metals; cutting of metals; lubrication of machines and cars; electric welding; the plastic flow of concrete under the pressure existing in large bridges, dams, and other structures.

"Summer schools for teachers in engineering colleges were assisted in 2 more successful sessions. Advanced courses for disengaged engineers, to be given without charge, were organized at the close of the year, to help improve mental equipment and maintain morale. Proposals for studies combining engineering and economics received extended consideration. Applications for aid to a number of projects for a variety of purposes had to be declined because of insufficiency of the Foundation's resources."

Outline of Joint Engineering Organizations

A brief résumé of the organization and objects of United Engineering Trustees, Inc., and its 3 departments, namely, the administrative department, The Engineering Foundation, and the Engineering Societies Library, follows:

United Engineering Trustees, Inc., was organized in 1904 under the name of the United Engineering Society "to advance the engineering arts and sciences in all their branches, to further research in science and in engineering, to maintain a free public engineering library, and to advance in any other manner the profession of engineering and the good of mankind." It is now the joint agency of the 4 national societies representing the civil, mining and metallurgical, mechanical, and electrical engineers.

Administrative Department

United Engineering Trustees, Inc., as the agency of these 4 societies, owns and administers the Engineering Societies Building at 33 West 39th Street, New York, N. Y., and the funds related thereto. It also administers the following trust funds: Engineering Foundation fund, library endowment fund, Henry R. Towne engineering fund, Edward Dean Adams fund, John Fritz Medal fund, and depreciation and renewal fund (for the Engineering Societies Building). Management of the building and all trust funds is in the hands of the administrative department of United Engineering Trustees, Inc., under the direction of its board of trustees.

The American societies of civil, mining and metallurgical, mechanical, and electrical engineers, through United Engineering Trustees, Inc., have equal interests in the ownership, occupancy, and administration of the building, which is run on a cooperative plan. The Engineering Societies Building houses also several other organizations in which engineers are interested.

The Engineering Foundation

The Engineering Foundation, founded by Ambrose Swasey (HM'28) is entrusted with the expenditure of the income of

endowments and other funds "for the furtherance of research in science and engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind." Its present preferred activity is engineering research. The Engineering Foundation cooperates with the 4 national engineering societies of which United Engineering Trustees, Inc., is the joint agency, with other organizations, and with individuals, in seeking additional knowledge through active, wisely directed research. It issues Research Narratives and other publications. It also has aided in establishing other research organizations.

Engineering Societies Library

The joint library of the national societies of civil, mining and metallurgical, mechanical, and electrical engineers is a free public library, which, with its numerous activities, is operated for users at a distance as well as for those who visit its rooms in the Engineering Societies Building. The library maintains a staff of technically trained searchers and translators, as well as reference assistants. It makes photoprints of any material in its collection and through a card service keeps subscribers informed of articles in periodicals on subjects in which they may be interested.

During the year a coordination committee of engineering societies was authorized with 3 members from each of the national societies of civil, mining and metallurgical, mechanical, and electrical engineers, and United Engineering Trustees, Inc. Through the efforts of this committee and its subcommittees, more effective action of the combined engineering societies is expected.

The real estate and funds of the corporation and contributions to it, and The Engineering Foundation and Engineering Societies Library, continue to be tax exempt.

United Engineering Trustees, Inc., has continued to act as treasurer and accountant for the Professional Engineers Committee on Unemployment of the New York-New Jersey metropolitan district, and for a small national relief fund.

An oil portrait of Herbert Hoover (HM'29) president of the United States, was committed to the custody of United Engineering Trustees, Inc., in February 1932, by the Hoover Medal Board of Award, on behalf of the 4 national engineering societies, and hung in the reading room of the library.

A summary of the accountants financial report of the administrative department for 1932 appears in Table I. In a companion article in this issue, an outline of the organization and objects of United Engineering Trustees, Inc., is given.

Annual Report Issued by United Engineering Trustees, Inc.

THE ANNUAL report of United Engineering Trustees, Inc., for 1932 has been submitted. In this report, submitted by H. A. Kidder (F'29) *president for 1932*, and Alfred D. Flinn, *secretary*, it is pointed out that assets for which the corporation is responsible (real estate at cost, "funds" at book value, and library as appraised) total nearly $4,000,000. All departments closed the year without deficit.

Table I—Summary of 1932 Financial Report

Operation of Building			
Operating Revenue		$115,459.64	
Less Operating Expenditures and Adjustments		107,020.89	
Net Operating Revenue		8,438.75	
Less Provision for transfer of Revenue to Depreciation and Renewal Fund (held in suspense)	$6,000.00		
Payment to Reserve for future Fire Insurance	800.00	6,800.00	
Net increase for year		$1,638.75	
Credit Balance in Activity Acct. Jan. 1, 1932		8,352.14	
Credit Balance in Activity Acct. Dec. 31, 1932			$9,990.89
Operation of Library			
Maintenance Revenue		$46,765.86	
Maintenance Expenditures		48,196.96	
Debit Balance for year 1932		−1,431.10	
Credit Balance from preceding years		4,352.21	
Total Credit Balance December 31, 1932			$2,921.11
Service Bureau Revenue		$9,481.24	
Service Bureau Expenditures and Adjustments		12,748.04	
Debit Balance for year 1932		−3,266.80	
Credit Balance from preceding years		4,343.35	
Total Credit Balance December 31, 1932			$1,076.55
Funds and Property			
Funds held by U.E.T., Inc., Dec. 31, 1932 (book value)			
Depreciation and Renewal Fund		$317,831.95	
General Reserve Fund		3,934.40	
Engineering Foundation Fund		783,049.13	
Henry R. Towne Engineering Fund		49,953.13	
Library Endowment Fund		174,544.32	
Edward Dean Adams Fund		100,000.00	
Total		$1,429,312.93	
Over-Investment of Combined Fund		121.06	1,429,433.99
Real Estate owned, cost to Dec. 31, 1932			1,987,793.92
Operating Cash, petty cash, and Inv. Oper. cash			13,320.62
Accounts Receivable			4,805.29
Endowment Committee Loan Receivable			1,700.00
Unexpired Fire Insurance Premiums			205.05
Fire Insurance Fund			5,400.00
Cash Advance to Engineering Foundation and Combined Fund			878.60
Total Assets—Administrative and Library			$3,443,537.47
Value of Library (as appraised approx. for Insurance)			$467,280.00
John Fritz Medal Fund (Custodian)			3,500.00

Election of United Engineering Trustees, Inc., Held

At a meeting of the board of trustees of United Engineering Trustees, Inc., held January 26, 1933, officers elected to serve for 1933 were announced. Harold V. Coes was elected president, Charles A. Mead, first vice-president, and R. M. Roosevelt, second vice-president. Dr. A. D. Flinn was elected to continue as secretary, and Clifford P. Hunt to continue as treasurer. Arthur S. Tuttle was elected assistant treasurer.

Appointments to the board of trustees for the 3-year term expiring January 1936 were announced to be as follows: C. W. Hudson, representing the American Society of Civil Engineers; William H. Bassett, representing the American Institute of Mining and Metallurgical Engineers; Harold V. Coes, representing The American Society of Mechanical Engineers; and H. P. Charlesworth (M'22, F'28, and president) representing the American Institute of Electrical Engineers. Other members of the board of trustees for the year 1933 (the first 4 having terms expiring in 1934, and last 4 having terms expiring in 1935), are as follows: Charles A. Mead, George D. Barron, Edwards R. Fish, H. A. Kidder, Arthur S. Tuttle, R. M. Roosevelt, William L. Batt, and A. W. Berresford.

The finance committee appointed by the board of trustees for the year 1933 is as follows: Charles A. Mead, *chairman*, R. M. Roosevelt, Edwards R. Fish, Arthur W. Berresford, and Harold V. Coes, ex-officio.

An outline of the organization and objects of United Engineering Trustees, Inc., is given in a companion article in this issue.

Personal

V. E. Bird (A'13) formerly assistant to the president and recently vice-president and general manager of the Connecticut Power Company, New London, has been elected president of that company to succeed Samuel Ferguson (A'02) who has been elected chairman of the board of directors. Mr. Bird continues as executive vice-president of the Hartford (Conn.) Electric Light Company. He has been associated with the electrical industry in New York for a number of years, having been sent to New London as manager of the Connecticut Power Company in 1913 when that organization was purchased by Stone and Webster interests. In addition to serving as an officer and on the directorate of several public utility companies, Mr. Bird also is an officer and director of several financial and industrial corporations.

G. A. Chutter (A'25) formerly electrical engineer for the General Electric Company, Milwaukee, Wis., has recently opened an office as consulting engineer in this city. Mr. Chutter has been designing engineer in the turbine engineering and industrial engineering departments of the General Electric Company. He is on the civic committee of the Milwaukee Engineering Society. Mr. Chutter received the degree of B.S. in E.E. in 1921, and the degree of M.S. in 1922, from Massachusetts Institute of Technology, Cambridge.

R. K. Bonell (A'24) formerly engineer of the Bell Telephone Laboratories, Inc., New York, N. Y., is now proprietor of The Tecna Company, Newark, N. J. The Tecna Company was established by Mr. Bonell to manufacture supplies for graphical statistics. Mr. Bonell received the degree of mechanical engineer from Stevens Institute of Technology in 1913, and later specialized in physics at the University of Michigan, leaving there in 1922.

C. E. Allen (A'04, F'14) commercial vice-president of the Westinghouse Electric and Manufacturing Company, who has been in charge of the manufacturing and sales activities of the merchandising department at East Pittsburgh, Pa., is now in St. Louis, Mo., in charge of the company's activities in that territory. Mr. Allen previously had served the company for some time as south-west district manager, with offices at St. Louis.

L. G. Pacent (M'18, F'30) formerly president and director of engineering and research for the Pacent Electric Company, Inc., and Pacent Reproducer Corp., New York, N. Y., has announced the opening of an office as a consulting engineer specializing in electrical, radio, sound, and motion picture fields, with laboratory facilities under the name of the Pacent Engineering Corporation, New York, N. Y.

F. O. Prior (M'26) formerly president of the Dixie Oil Company, Inc., Tulsa, Okla., is now president of the Standard Oil and Gas Company, of Tulsa. Mr. Prior is a member of the American Institute of Mining and Metallurgical Engineers, and of the American Petroleum Institute. He graduated from the mechanical engineering department of Leland Stanford Jr. University in 1918.

E. W. Kimbark (A'27) formerly assistant curator of motive power and transportation, Museum of Science and Industry, Chicago, Ill., is now a graduate student in the electrical engineering department of the Massachusetts Institute of Technology, Cambridge A, Mass. Mr. Kimbark, graduated from Northwestern University with the class of 1924, receiving his engineering degree from this university in 1925.

E. S. Henningsen (A'20, M'26) formerly engineer in the a-c engineering department, General Electric Company, Schnectady, N. Y., has recently been appointed engineer-in-charge of the newly created motor and generator engineering department of this company. This department takes over all the responsibility of the former a-c and d-c engineering departments.

William Goodridge (A'28) formerly in the New York sales division of the International General Electric Company, New York, N. Y., is now sales agent for Johnson and Phillips, Ltd., of London, England; C.G.S. Measuring Instruments, of Monza, Italy; and other companies. His office is in New York.

L. F. Crabtree (A'31) formerly installer for the Automatic Electric Company, Inc., of Chicago, Ill., has recently joined the organization of the Public Service Company of Northern Illinois. He graduated from Rensselaer Polytechnic Institute, department of electrical engineering, in 1930.

L. N. Robinson (A'13, F'25) formerly engineer with the Stone and Webster Engineering Corp., Boston, Mass., has opened offices in Corning, N. Y., for continuing his practice as a consulting engineer. Doctor Robinson has been engaged for more than 20 years on important engineering developments.

S. L. Nicholson (A'00, F'13) acting vice-president of the Westinghouse Electric and Manufacturing Company, New York, N. Y., has been appointed a director of the American Standards Association on the nomination of the National Electrical Manufacturers Association.

J. L. Burnham (A'06, M'27) formerly designing engineer of the a-c engineering department of the General Electric Company, Schenectady, N. Y., has been appointed designing engineer of the newly created motor and generator engineering department of this company.

P. M. Downing (A'98, M'08) first vice-president and general manager of the Pacific Gas and Electric Company, San Francisco, Calif., has been elected treasurer of the San Francisco chamber of commerce after several terms as a director.

Samuel Ferguson (A'02) president of the Hartford (Conn.) Electric Light Company and formerly president of the Connecticut Power Company, New London, has been elected chairman of the board of directors of this latter organization.

I. A. Terry (A'27) formerly design engineer in the a-c engineering department, General Electric Company, Schenectady, N. Y., has been appointed assistant engineer of the newly created motor and generator engineering department of this company.

J. A. G. Oewel (A'32) formerly assistant to the relay engineer of the Pennsylvania Power and Light Company, Hazleton, Pa., is now assistant to the local test engineer of this company at Mt. Carmel, Pa.

J. S. Thompson (A'14) president, the Pacific Electric Manufacturing Company, San Francisco, Calif., has been elected a director of the San Francisco chamber of commerce.

Obituary

William Lispenard Robb (A'91, M'92, F'13, and member for life) professor of electrical engineering and physics and head of the department of electrical engineering at Rensselaer Polytechnic Institute died on January 26, 1933 at Troy, N. Y. He was born in 1861 at Saratoga Springs, N. Y. He graduated from Columbia University with the degree of bachelor of arts in 1880. Doctor Robb was awarded a Columbia University fellowship and was one of the first of the young American students to go abroad to study science. He spent 2 years at the University of Wurzburg, and after another year of study at the University of Berlin, was given the degree of doctor of philosophy by the latter institution in 1883. In Germany, Doctor Robb studied under such eminent physicists as Kohlrausch, von Helmholtz, and Kirchoff. Returning to America, he became assistant professor of mathematics in the school of mines at Columbia University. In 1885, he accepted the chair of physics at Trinity College, Hartford, Conn., and served at that institution for 17 years, except for brief intervals spent in travel and in government service during the Spanish-American War, when he was in charge of mine laying in New York harbor. In 1892, Doctor Robb returned to Europe to spend a year in study at the Federal Polytechnic Institute at Zurich, Switzerland. In 1902, he was honored with the degree of LL.D. from Trinity College and in the same year went to Troy to form the electrical engineering

department at Rensselaer Polytechnic Institute. He was head of that department at the time of his death. In 1932 he was given the honorary degree of doctor of engineering by Rensselaer Polytechnic Institute. Doctor Robb played a prominent part in the development of the electrical industry in this country, especially in the public utility field. He was well known as a consulting engineer and was associated in that capacity with the New York Shipbuilding Corporation, the General Electric Company, the Aluminum Company of America, the General Railway Signal Company, and the Hartford Electric Light Company. He served the latter company for more than 35 years, and was still active in its employ at the time of his death. Doctor Robb was a member of the American Physical Society, the New York Academy of Sciences, the Delta Phi and Phi Beta Kappa fraternities, the Society of the Sigma Xi, the Troy Club and the Engineers' Club of New York, N. Y. He was an honorary member of the Rensselaer Society of Engineers and a former trustee of the Troy Public Library.

William Henry Blood, Jr. (A'05, M'06, F'13) vice-president of Stone and Webster Engineering Corp., of Boston, Mass., died suddenly February 13, 1933. He was born in Charlestown, Mass., in 1866. In 1888 he graduated from the electrical engineering department of Massachusetts Institute of Technology, and spent the following 2 months with the Mather Electric Company at South Manchester, Conn., in charge of tests on instruments, motors, etc. He then spent about a year with the Thomson-Houston Electric Company, Lynn, Mass., designing and testing many motors, generators, and transformers. He then spent a year with the Northwest Thomson-Houston Company, Minneapolis, Minn., in charge of the repair department. Between 1891 and 1896 he maintained his own business in Kansas City, Mo., doing a general engineering and construction business. Besides designing and building a number of power plants, he built 2 electric automobiles about 1893. Returning to Boston early in 1896, Mr. Blood had charge of the manufacturing department of the Chase-Shawmut Company, manufacturing electrical specialites, until he joined the organization of Stone and Webster in 1897. With this organization he has made many studies of electrical properties throughout the country, and reported upon valuations and methods of improving operation. He has been an expert consultant in many cases, and has made general designs of a number of important installations. For the last few years he has had charge of the appraisal of all Stone and Webster properties. Mr. Blood was president of the National Electric Light Association in 1905 and 1906, and has been president of the Electric Vehicle Association of America. He was a Fellow of the American Gas Association, and a member of the Illuminating Engineering Society, the National Fire Protection Association, the National Conference on Standard Electric Rules, of which he was president from 1906 to 1911, and the Association of Edison Illuminating Companies. He also was a member of the Exchange Club of Boston, the Lawyers' Club of New York, the Wellsley Club, the Camden (Maine) Yacht Club, and the Boothbay Harbor (Maine) Yacht Club. In 1917 and 1918 he served as assistant to the president of the American International Shipbuilding Corporation. For several years he was a lecturer on public utilities at the Harvard Graduate School of Business Administration.

Robert Manson Wilson (A'99, F'13) who previous to his retirement had been general superintendent and chief engineer of the Montreal Light, Heat, and Power Company, died January 4, 1933, after a long illness. Mr. Wilson was born in Montreal, Quebec, in 1874. He left school in 1890, working first for 2 years for the Canadian Pacific Railroad, followed by one year in the drafting room of the Royal Electric Company, and 2 years in the test department of this company. In 1895, he returned to college, becoming an honor graduate of McGill University, Montreal, with the degree of bachelor of science in 1899. Late in 1899 he became assistant superintendent of the hydroelectric plant on the Richelieu River for the Chambly Manufacturing Company, after having had charge of the electrical construction of this plant. A short time later he returned to the Royal Electric Company as assistant to the general superintendent, holding this position until 1902 when an amalgamation of the Royal Electric Company and others under the name of the Montreal Light, Heat, and Power Company took place. He was then appointed superintendent of all power plants and substations, holding this position until 1904 when he was appointed general superintendent of the company. In 1909 he was appointed chief engineer, retaining the position of general superintendent as well. In 1913 he was appointed, with his other duties, chief electrical engineer of the Cedar Rapids Power Company. In 1925 he resigned from active service and in 1926 resigned the directorship to which he was elected in 1920.

Delos Emmons Parsons (A'27) New York district manager for the Railway and Industrial Engineering Company of Greensburg, Pa., died January 28, 1933, at his home in Millburn, N. J. Mr. Parsons was born at Huntington, W. Va., in 1882. Following graduation from West Virginia University, Morgantown, W. Va., he was on the apprenticeship course of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., between 1903 and 1905, following which he was in sales engineering work with this company until 1916. During this period he was in the export sales department from 1905 until 1908, in the mining sales department until 1911, and then in the railway and lighting sales department. Between 1916 and 1924, he was general manager of public utility properties for the East St. Louis and Suburban Railway Company, East St. Louis, Ill. While in Illinois he was active in the affairs of the electrical associations, having been president of the Illinois Electric Association and of the Illinois Railway Association. In 1924, he become identified with the Railway and Industrial Engineering Company, first as district sales manager of the Philadelphia territory, and in 1928 district manager for the New York territory.

Harry William Hadlock (A'19) electrical engineer of the Associated Factory Mutual Fire Insurance Company, Boston, Mass., died January 29, 1933. Mr. Hadlock was born in Naples, Maine, in 1887. He studied electrical engineering for 2 years at the University of Maine, and graduated from Lowell Institute after one year of study accompanied by night courses at Massachusetts Institute of Technology. He was engaged in electrical construction for the Lundin Electric and Machine Company, Boston, Mass., between 1909 and 1910, following which he was engaged in station operating for the Edison Electric Illuminating Company of Boston, Mass., until 1912. Between 1912 and 1917, he was assistant station superintendent for this latter company. He then became assistant electrical engineer for what is now the Associated Factory Mutual Fire Insurance Company at Boston, Mass., later becoming electrical engineer of this organization.

Franklin Wesley Springer (A'00, M'01, F'13) professor of electrical engineering, University of Minnesota, Minneapolis, died in that city January 23, 1933, after a lingering illness of several years. He was born in 1870 in Anoka, Minn. In 1893 he graduated from the University of Minnesota, with the degree of B.E.E., the degree of E.E. being obtained 3 years later. In the summer of 1892 he was in the employ of the Twin City Rapid Transit Company of St. Paul and Minneapolis, as motor inspector. After graduating in 1893 he returned to the Twin City Rapid Transit Company and held various positions in the mechanical, electrical, and operating departments of this company until 1896, when he went into partnership with W. W. Dakin for the manufacture of scientific instruments. In 1898 he was appointed instructor of electrical engineering at the University of Minnesota, being made assistant professor of electrical engineering in 1900. He was made a full professor in 1908, and held this position until the time of his death. Professor Springer had to his credit 20 patents covering laboratory equipment and service arrangements, and in the course of his academic career contributed numerous reports and articles to the technical press. He was a member of the Society for the Promotion of Education, and a member of Delta Upsilon fraternity.

Frank Rudolph Schmidt (A'27) assistant engineer, New York Edison Company, New York, N. Y., died January 19, 1933. He was born in New Rochelle, N. Y., 1906. Following a 3-year course at preparatory school, he studied 2 years at the New York Edison school. He had been with the New York Edison Company since 1922, spending a year in the armature de-

partment, another year as electrical tester, and a third in construction, testing, and maintenance of outdoor station equipment. The last half of 1925 he was engaged in a series of special measurements of alloy and base metals used in generating and conversion equipment. Following several months in 1926 as maintenance man and inspector of rewinding jobs, he was placed in the office of the general superintendent of distributing stations handling reports of tests, installation of new equipment, and alterations.

YOSINOBU MATUNAGA (A'26) research physicist of the Shibaura Engineering Works, Ltd., Tsurumi, Yokohama, Japan, died December 15, 1932. He was born at Kumamoto, Japan, in 1899. In 1924 he graduated from the Institute of Physics, Science College, Tokyo Imperial University and was then appointed research engineer in the research laboratory of the Shibaura Engineering Works, Ltd., first engaged in a study of metal case mercury arc rectifiers at Tokyo, before being transferred to Yokohama.

Local Meetings

Pittsburgh Section Meets With Neighboring Student Branches

The annual joint meeting of the Pittsburgh Section and the Student Branches at Carnegie Institute of Technology, University of Pittsburgh, and West Virginia University, was held in the high tension laboratory of the Duquesne Light Company, on January 10, 1933, with an attendance of 185. The following technical papers were presented:

J. Davis Young, chmn., U. of P., presiding.
THE TOLL LINE BETWEEN MARTINSBURG, W. VA., AND WINCHESTER, VA., by P. M. Vannoy, W. Va. U.
POWER RECTIFIERS, by D. C. Dieterly, C.I.T.

R. H. Colborn, chmn., W. Va. U., presiding.
WORK AND AN ENGINEERING EDUCATION, by H. A. Kent, U. of P.
ELECTRIC SHOCK, by R. A. Mylius, C.I.T.

W. R. Uffelman, chmn., C.I.T., presiding.
TRANSMISSION OF POWER WITH CONTINUOUS CURRENTS, by F. Q. Brown, W. Va. U.
ELECTRICAL CONSIDERATION OF PROBLEMS IN PAPER MANUFACTURE, by A. A. Currie, U. of P.

Discussion of papers with J. Davis Young, *chmn.*, U. of P. presiding.

Demonstration of surge generator by E. H. Whitehead and D. B. Perrin, Duquesne Light Company.

Following dinner at Fort Pitt Hotel and talks by several students, H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell. Tel. Labs., Inc., gave an address entitled "New Frontiers Through Research and Engineering."

Student Branch Organized at University of Porto Rico

The formation of a Student Branch of the Institute at the University of Porto Rico was authorized by the executive committee at its meeting on December 6, 1932. The Branch has completed its organization and the following officers are in charge:

Osvaldo P. Doria, *chairman*
Ramiro Marquez, *vice-chairman*
Carlos R. Nadal, *secretary*
Rafael P. Valls, *treasurer*

Prof. George F. Anton has been appointed Counselor of the Branch.

Future Section Meetings

Boston

March 14—FUSES.
April 11—PROGRESS OF FIFTY YEARS IN THE ELECTRICAL INDUSTRY, by Dr. A. E. Kennelly, Harvard Univ.

Cleveland

March 16—SOME ELECTRIC ELEVATOR PROBLEMS, by D. L. Lindquist, Otis Elevator Co.
April 20—Joint meeting with Case Sch. of Applied Science Branch.

Detroit-Ann Arbor

March 21, at Ann Arbor, Mich.—TELEPHONE TRANSMISSION, by Dr. H. S. Osborne, Am. Tel. & Tel. Co.
April 18, at Detroit Edison Auditorium—MODERN THEORIES OF THE COMPOSITION OF MATTER, by Prof. A. H. Compton, Univ. of Chicago.

Fort Wayne

March 14—MODERN METHODS AND EQUIPMENT FOR POWER SUPERVISION, by G. A. Grimm, Indiana Serv. Corp.; SOME MODERN PROTECTIVE RELAYS, by V. Verrall, Genl. Elec. Co.
April 18—RECENT DEVELOPMENT IN TRANSPORTATION, by W. M. Guynes, Genl. Elec. Co.

Lehigh Valley

March 10, at Hotel Casey, Scranton, Pa. SYMPOSIUM ON ELECTRIC CONTROL, by F. L. Stone, Genl. Elec. Co., D. L. Pierce, Westinghouse Elec. & Mfg. Co., and H. P. Chandler, Ohio Brass Co.

Pittsfield

March 7—EXPERIENCES OF A GANG BUSTER, by Capt. C. W. Willemse.
March—Competitive meeting with Schenectady Section.

Toronto

March 10—ERECTION OF LARGE SYNCHRONOUS GENERATORS, by F. Hoffmeister.
March 24—Open.
April 14—Joint meeting with Engrg. Inst. of Canada at Hamilton, Ont.
April 28—Annual meeting.

Past Section Meetings

Akron

VISIBLE SOUND, by Dr. D. C. Miller, Case Sch. of App. Science. Dinner. Jan. 10. Att. 802.

Baltimore

ELECTRICITY IN THE HOME, by Mrs. Alyce Lyttle, Consolidated Gas, Elec. Lt. and Pwr. Co. Dec. 16. Att. 55.
RAILROADS CONSOLIDATIONS, by D. Willard, Baltimore & Ohio RR. Dinner. Jan. 9. Att. 350.

Boston

INTERNATIONAL COMMUNICATIONS, by H. S. Osborne, Am. Tel. & Tel. Co. Motion pictures. Jan. 10. Att. 200.

Chicago

POWER SYSTEM LOSS ANALYSIS, by L. R. Janes, Pub. Serv. Co. of No. Ill. Illus. Jan. 10. Att. 82.
NEW DEVELOPMENTS IN ELECTRICAL ENGINEERING, by S. M. Kintner, Westinghouse Elec. & Mfg. Co. Joint meeting with Western Soc. of Engrs. Jan. 16. Att. 286.

Cincinnati

C. H. Rembold, Cincinnati Times-Star, L. L. Bosch, Columbia Engg. & Mgmt. Corp., and A. H. Parks, Cline Elec. & Mfg. Co., described the history, features of the power supply, and major problems in connection with the Cincinnati Times-Star installations. An inspection trip through the plant followed. Jan. 12. Att. 250.

Columbus

THE HUMAN SEEING MACHINE, by Dr. M. Luckiesh, Genl. Elec. Co. Dinner. Jan. 27. Att. 350.

Connecticut

ARC PHENOMENA AND CIRCUIT INTERRUPTERS, by Dr. Joseph Slepian, Westinghouse Elec. & Mfg. Co. Jan. 10. Att. 125.

Dallas

RECENT DEVELOPMENTS IN METERING ELECTRICAL ENERGY, by M. P. Jones; RADIO CONTROL TRAIN, by J. Walker and D. Ramsey; REPORT OF SOUTHWESTERN DISTRICT STUDENT CONVENTION, by R. Porter Lindsley, students. Joint meeting with Southern Methodist Univ. Branch. Jan. 23. Att. 39.

Denver

DE-BUNKING THE ENGINEER, by F. R. Jamison, Pub. Serv. Co. of Colo. Dinner. Dec. 16. Att. 70.
PROGRESS IN PHYSICAL SCIENCE, by Dr. R. E. Nyswander, Univ. of Denver. Dinner. Jan. 20. Att. 34.

Detroit-Ann Arbor

EXTENDING OUR FRONTIERS THROUGH RESEARCH AND ENGINEERING, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc. Jan. 17. Att. 275.

Fort Wayne

DIAL CONTROLLED ROBOTS, by H. M. Bruckart, Home Tel. & Tel. Co. Jan. 17. Att. 125.

Houston

MEASUREMENT OF THREE PHASE POWER, by E. Yarborough, student, Texas A. & M. College; CRYSTAL DETECTORS, by M. E. Chun, student, Rice Institute. Joint meeting with Texas A. & M. College and Rice Inst. Branches. Jan. 28. Att. 45.

Indianapolis-Lafayette

EXTENDING OUR FRONTIERS THROUGH RESEARCH AND ENGINEERING, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc. Illus. Jan. 16. Att. 166.

Ithaca

MANUFACTURING PRACTICES THAT DETERMINE PERFORMANCE OF VACUUM TUBES IN THE FIELD, by W. R. Jones, Hygrade Sylvania Corp. Joint meeting with Cornell Univ. Branch. Jan. 20. Att. 85.

Kansas City

COMMUNICATION AIDS TO AVIATION, LAYING PARTICULAR STRESS ON THE RADIO, by John Casey, Southwestern Bell Tel. Co. Jan. 19. Att. 60.

Lehigh Valley

ELECTRIC WELDING, by Col. Royal Mattice, Mattice Engg. Co. Film—"Buried Sunshine." Meeting held in Pottsville, Pa. Jan. 13. Att. 100.

Los Angeles

PHYSICS OF ALTERNATING CURRENT PHENOMENA, by Lamar Lyndon. Illus. Dinner. Jan. 10. Att. 117.

Madison

THE FOREST PRODUCTS LABORATORY AND ITS PROGRAM, by C. P. Winslow; HOUSE PAINTING PROBLEMS, by F. L. Browne; RECENT RESEARCH IN TIMBER FRAMING, by G. W. Trayer. Inspection trip through the new Forest Products Lab. Jan. 9. Att. 122.

Memphis

Industrial Power, by M. M. Masson, Memphis Pwr. & Lt. Co. Jan. 17. Att. 46.

Mexico

Juan Ramirez de Arellano, Pachuca Lt. & Pwr. Co., described the curriculum of the new Polytechnic Inst. of Pachuca. Jan. 21. Att. 62.

Milwaukee

Mercury Arc Rectifiers, by W. E. Futzwiller, Allis Chalmers Mfg. Co. Illus. Dec. 7. Att. 90.

Motion pictures. Joint meeting with Engrs. Soc. of Milwaukee. Dec. 21. Att. 125.

Discussion of the isolated power plant by C. A. Cahill, consulting engr., B. V. E. Nordberg, Nordberg Mfg. Co., and L. H. Stark, National Knitting Co. Joint meeting with Engrs. Soc. of Milwaukee. Jan. 18. Att. 200.

Inspection trip to the Allis-Chalmers Mfg. Co. plant. Jan. 21. Att. 375.

Montana

Performance of an A-C Electric Mine Hoist, by W. A. Boyer, Anaconda Copper Mining Co. Joint meeting with Montana Soc. of Engrs., at Butte, Montana. Jan. 9. Att. 63.

New York

Mercury Turbo Generator, by H. N. Hackett, Gen. Elec. Co., and Darrow Sage, Pub. Serv. Elec. & Gas Co. Power Group. Feb. 8. Att. 300.

The Power Supply of the Pennsylvania Railroad, by J. V. B. Duer, Pennsylvania RR. Transportation Group. Jan. 11. Att. 650.

Solving the Decorative Lighting Problems in Radio City, by Prof. S. R. McCandless, Yale Univ.; The Electrical Equipment of Radio City Theaters, by Eugene Braun, RKO Music Hall. Joint meeting with Illumination Group and N. Y. Section I.E.S. Feb. 7. Att. 1200.

Niagara Frontier

Industrial Electric Heating—From Comparison, by C. P. Yoder, Buffalo, Niagara & Eastern Pwr. Corp. Jan. 20. Att. 60.

Oklahoma City

The Contribution of Telephone Research to Talking Motion Pictures, by Dr. J. O. Perrine, Am. Tel. & Tel. Co. Dinner. Nov. 15. Att. 130.

Practical Uses of Electrical Apparatus in Medicine, by Dr. Elias Margo, McBride Clinic and Reconstruction Hospital. Jan. 10. Att. 60.

Improvement of Plant Construction Conditions and Power Arc Follow-Up Demonstration, by R. L. Jones, Southwestern Bell Tel. Co., and R. W. Coursey, Oklahoma Gas & Elec. Co. Jan. 31. Att. 140.

Philadelphia

The Studio and Transmitter Installation at WCAU, by J. E. Love, RCA Victor Co.; Scope and Structure of the WCAU Studios, by Dr. Leon Levy, WCAU Broadcasting Co. Jan. 9. Att. 480.

Pittsfield

Modern Railway Electrification with Special Reference to the Pennsylvania System, by J. V. B. Duer, Pennsylvania RR. Jan. 17. Att. 132.

Portland

Army Engineers Report on the Columbia River Development, by H. A. Rands, U. S. Army Engrs. Jan. 10. Att. 69.

Providence

Arc Phenomena and Circuit Interrupters, by Dr. Joseph Slepian, Westinghouse Elec. & Mfg. Co. Illus. Dinner. Jan. 12. Att. 50.

Rochester

Engineering Problems of Power System Interconnection, by J. Allen Johnson, vice-pres., A.I.E.E., Buffalo, Niagara and Eastern Power Corp. Joint meeting with I.R.E. and Rochester Engg. Soc. Jan. 12. Att. 82.

St. Louis

The Proper Application of Electrical Equipment in Industry, by L. F. Woolston, Genl. Elec. Co. Jan. 18. Att. 43.

San Francisco

Economics, Engineering, Technocracy, by Dr. Nathan A. Bowers, McGraw-Hill Pub. Co., Rupert Kempf, Best Foods Products Co. and Prof. W. A. Hillebrand, Univ. of Calif. Jan. 20. Att. 700.

Schenectady

Charles C. Parlin, Curtis Publishing Co., discussed the steps required in producing magazines such as the *Saturday Evening Post*. Joint meeting with A.S.M.E. Section. Dinner. Jan. 12. Att. 100.

Russian Geography and the Five Year Plan, by Prof. Ellsworth Huntington, Yale Univ. Joint meeting with A.S.M.E. Section. Dinner. Jan. 26. Att. 400.

Sharon

Crossing Bridges and Scaling Stone Walls, by Dr. C. E. Skinner, formerly asst. director of engg., Westinghouse Elec. & Mfg. Co. Film—"The Triumph of the Century." Jan. 10. Att. 215.

Springfield

Arc Phenomena and Circuit Interrupters, by Dr. Joseph Slepian, Westinghouse Elec. & Mfg. Co. Illus. Joint meeting with Engg. Soc. of Western Mass. Dinner. Jan. 11. Att. 150.

Syracuse

An Engineer's Experience in Russia, by W. P. Creager, Niagara-Hudson Corp. Jan. 9. Att. 317.

Toledo

D.C. Distribution Systems, by C. J. Taylor, Toledo Edison Co.; Air Conditioning, by H. B. Metzen, Carrier Corp. Jan. 13. Att. 75.

Toronto

Coordination and Protection of Insulation, by W. W. Lewis, Genl. Elec. Co. Jan. 13. Att. 85.

Distant Universes, by Prof. C. A. Chant, Univ. of Toronto. Jan. 27. Att. 83.

Utah

The Conduction of Electricity Through Gases and the Application to Arc Extinction, by F. E. Young, Jr. Dec. 12. Att. 15.

New Developments of Supervisory Control Equipment, by P. B. Garrett, Westinghouse Elec. & Mfg. Co. Illus. Jan. 9. Att. 55.

Washington

The Teletypewriter, by G. L. Weller, C. & P. Tel. Co. Film—"The Modern Knight." Dinner. Jan. 10. Att. 105.

Worcester

Inspection trip through the Worcester Telegram Gazette building. Jan. 13. Att. 60.

Past Branch Meetings

Alabama Polytechnic Institute

Smoker. Jan. 26. Att. 17.

University of Alabama

Advancement of the Electric Light Bulb, by Mr. Thorton, Alabama Pwr. Co. Jan. 30. Att. 150.

University of Arizona

The Work of the Observatory, by A. K. Ludy, U.S. Magnetic Observatory. Dec. 8. Att. 17.

Remote Radio Control, by R. Carson, student. Dec. 9. Att. 6.

Acoustics, by J. Jones, student. Jan. 6. Att. 5.

The Thyratron, by B. Watkins, student. Jan. 13. Att. 7.

Business meeting. Jan. 20. Att. 6.

University of Arkansas

Electrical Heat Insulators, by E. A. Howell, student; Electrical Heating Elements, by W. H. Mayhan, student. Jan. 12. Att. 24.

Armour Institute of Technology

Photoelectric Cells and Their Applications, by R. B. Kellogg and E. J. Pahelan, Commonwealth Edison Co. Jan. 13. Att. 50.

University of British Columbia

Colonel Crompton, by F. Bolton; Dr. Hopkinson, by D. McMynn; Ferranti, by L. Rader; Alexander Graham Bell, by G. Nixon, all students. Jan. 12. Att. 23.

Hydraulic Couplings, by J. Deane; The Fourth Unit of the Jordan River Power Development, by J. V. Rogers; Mercury Arc Rectifiers, by R. Deane, all students. Jan. 26. Att. 20.

Polytechnic Institute of Brooklyn

Mercury Arc Rectifiers, Their Operation and Use, by C. Petersen; An Experimental Study of Leakage Flux and Iron Losses in a Constant Current Transformer, by A. Cuciti; Some Methods of Studying Vibrations, by F. Anderson, all students. Jan. 11. Att. 38.

University of California

Personnel Management, by E. G. McCann, Pacific Gas & Elec. Co. Feb. 2. Att. 54.

Clemson Agricultural College

Pulp Insulation for Telephone Cables, by G. A. Harvin; Economic Aspects of Water Power, by N. G. Forb; Current Events, by P. Quattlebaum, students. Jan. 10. Att. 29.

Vibration in Electrical Conductors, by I. M. Watson; Injuries From Electric Shock, by W. J. Burton; Brass Tacks in Economics, by R. B. Shores; Current Events, by L. I. James, students. Jan. 31. Att. 30.

Colorado Agricultural College

The Progress in Electric Welding, by Carl Schock, student; Prospecting by Radio, by Charles Shields, student. Jan. 9. Att. 9.

The Loveland Municipal Light Plant, by Ray Smith, city engr. Jan. 23. Att. 7.

University of Colorado

The Development of Railway Signaling, by John C. Law, student. Jan. 11. Att. 30.

Cooper Union

Electronics, by W. S. Hill, Genl. Elec. Co. Jan. 12. Att. 44.

Cornell University

Manufacturing Practices That Determine Performance of Vacuum Tubes in the Field, by W. R. Jones, Hygrade Sylvania Corp. Joint meeting with Ithaca Sec. Jan. 20. Att. 85.

University of Florida

The X-Ray—Its Industrial Applications, by Dr. A. A. Bless. Jan. 10. Att. 102.

University of Idaho

Films—"Liquid Air," "Queen of the Waves," "King of the Rails," "Automatic Substation," and "Great Deeds." Jan. 16. Att. 34.

Iowa University

High Wattage Lighting, by Robert Hawley; Sodium Gas Lighting, by Raymond Judd; Velocity Microphone, by J. H. Hahn, all students. Jan. 4. Att. 31.

A Western Maryland Power Station, by R. B. Miller, student; Technocracy, by M. J. Larsen, student. Jan. 11. Att. 31.

University of Kansas

Election of officers: J. Doolittle, chmn.; Ralph Cheney, vice-chmn.; Richard Foor, secy.; Paul Grist, treas. Jan. 18. Att. 32.

Lafayette College

The Kennelly-Heaviside Layer, by G. D. Hegeman, Jr., student; Symmetrical Components, by F. H. Welsh, student. Jan. 13. Att. 25.

Lehigh University

The Cash Register of the Power Company, by R. P. Lee, student; Grounding, by Glen Appleman, Penn. Pwr. & Lt. Co. Jan. 12. Att. 38.

Lewis Institute

Business meeting. Dec. 1. Att. 35.

Your Future Job, by Paul B. Juhnke, Commonwealth Edison Co. Joint meeting with Western Soc. of Engrs. Dec. 8. Att. 180.

University of Louisville

Films—"Oil Circuit Breakers" and "Synchronous Selector Supervisory System." Jan. 18. Att. 17.

University of Maine

The Advantages of Being Affiliated With the A.I.E.E., by Dean Paul Cloke. Jan. 6. Att. 22.

When the Answer Isn't in the Book, by H. W. Coffin, Bangor Hydroelectric Co. Jan. 19. Att. 28.

Michigan College of Mining and Technology

Television, by J. M. Sanabria, student; Scott All-Wave Radio, by F. J. Plaga, student. Jan. 19. Att. 46.

Michigan State College

Discussion. Jan. 11. Att. 27.

University of Michigan

THE BLONDEL METHOD OF ANALYZING THE SYNCHRONOUS MOTOR, by M. E. Berman, student. Film—"From Coal to Electricity." Jan. 12. Att. 20.

STRAIGHT THINKING, by C. F. Hirshfield, Detroit Edison Co. Jan. 23. Att. 70.

School of Engineering of Milwaukee

ENGINEERING IN INDUSTRY, by James Brower, Milwaukee Sewerage Disposal Commission. Jan. 11. Att. 65.

University of Minnesota

Inspection trip through the new Northwestern Telephone building. Jan. 18. Att. 35.

Montana State College

INDUCTION MEETING OF STEEL ALLOYS, by L. Ambrose; METAL DISPOSITION IN ELECTRIC ARC WELDING, by R. V. Bauer; PITTSBURGH'S CONTRIBUTIONS TO RADIO, by J. Cromer; THE GIANT'S VOICE, by T. E. Degenhart; A ROTARY VOLTMETER, by L. A. Eisele, all students. Jan. 12. Att. 71.

HIGH FREQUENCY FOR ARC WELDING, by C. L. Grebe; DECORATING THE GARDEN WITH KILOWATTS, by J. M. Joyce; LIGHTNING EXPERIENCE ON WOOD POLE LINES, by J. G. Lightfoot, all students. Jan. 19. Att. 61.

INFANTRY COMMUNICATION, by D. A. Nauck; ELECTROLYSIS OF GOLD ORES, by E. Rothfus; TELETYPE AVIATION, by C. Schmitz; Oxide Coatings on Aluminum, by R. Wyman; THE DEVELOPMENT OF THERMIONIC TUBES, by C. Angle; MILL OPERATES ON FULL-TIME SCHEDULE, by A. Antonich, all students. Jan. 26. Att. 61.

THE BUILDING OF MOTOR-GENERATOR SETS, by W. L. Rightmire. Feb. 2. Att. 67.

University of Nebraska

A NEW METHOD FOR STARTING INDUCTION MOTORS, by A. L. Coffin and J. B. Cecil, students. Election of officers: John Brewer, chmn.; Max Mattison, vice-chmn.; Henry W. Bauer, secy.-treas., Jan. 11. Att. 15.

University of Nevada

ELECTRIC DREDGING MACHINERY AT NEW GUINEA GOLD PROPERTIES, by H. B. Hodgins, Westinghouse Electric & Mfg. Co. Jan. 19. Att. 25.

University of New Hampshire

LIGHTNING, by Philip Nudd, student. Jan. 14. Att. 29.

POWER FACTOR METERS, by H. W. Feindel, student. Jan. 21. Att. 29.

New York University

MERCURY ARC RECTIFIERS, by Daniel Neary; DUST PRECIPITATION BY ELECTRICITY, by Carl Zimmermann; THYRATRON TUBES, by F. Wilhelm, all students.

North Carolina State College

A MECHANICAL DEVICE FOR REPRESENTING POTENTIAL GRADIENT, by F. E. Brammer, student. Jan. 17. Att. 32.

LIGHTNING AND SIMILAR CAUSES OF TRANSMISSION LINE TROUBLES, by R. P. Crippen, Carolina Pwr. & Lt. Co. Jan. 31. Att. 53.

University of North Carolina

OSCILLOGRAPHS, by J. R. Marvin; STATION WBT, by T. L. Cordle; THE EFFECTS OF ELECTRIC SHOCKS, by W. J. O'Brien, all students. Jan. 10. Att. 30.

Annual inspection trips to the Norwood Power Station of the Carolina Pwr. & Lt. Co., The Southern Bell Tel. & Tel. Co., The Southern Pub. Utilities Co., and Station WBT. Jan 27–28. Att. 12.

University of North Dakota

ELECTRICAL WELDING, by E. Dubuque, student; CAPACITOR MOTORS, SINGLE AND POLYPHASE, by C. Clemetson, student. Jan. 11. Att. 19.

University of Notre Dame

MICROPHONES, by C. Foote, student; PROBLEMS OF TELEVISION, by W. Mitsch, student; ARC WELDING IN MANUFACTURING, by R. D. Layman, Lincoln Elec. Co. Jan. 11. Att. 55.

Ohio University

PUBLIC UTILITIES, by Howard Bobo and Fred McKay, Southern Ohio Elec. Co. Dinner. Jan. 11. Att. 32.

Oklahoma A. & M. College

THE RELATION OF BACTERIOLOGY TO ENGINEERS, by Dean C. H. McElroy. Nov. 7. Att. 18.

Films—"The Story of Dynamite," "Sulphur," "The Life of Edison," and "The X-Ray." Nov. 21. Att. 35.

THE ADVANCEMENT OF THE MACHINE AGE, ESPECIALLY AS RELATED TO AGRICULTURE, by Prof. L. E. Hazen. Dec. 5. Att. 20.

STANDARDIZATION IN INDUSTRY, by Prof. DeWitt Hunt. Jan. 9. Att. 25.

University of Oklahoma

CONTROL OF ELECTRIC SIGNS, by J. B. Bender; THE GOODYEAR-ZEPPELIN PLANT AT AKRON, by Herbert Moody, students. Jan. 26. Att. 19.

Oregon State College

CHEMICAL WARFARE, by Dr. Caldwell. Film—"The Eyes of Industry." Joint meeting with A.S.M.E. and A.I.Ch.E. Branches. Jan. 12. Att. 100.

A HISTORY OF THE INCANDESCENT LAMP, by Fred Helber; ULTRA SHORT WAVES, by Tom Wagner and Wm. Miller; A TRIP THROUGH EUROPE, by Frank Gilbert, all students. Jan. 26. Att. 34.

Purdue University

Film—"Nature's Frozen Credits." Jan. 10. Att. 75.

Rhode Island State College

ARC OSCILLATOR, by Mr. Durfee and Mr. Lang, students. Demonstration. Jan. 12. Att. 23.

Film—"Conowingo." Jan. 26. Att. 20.

University of South Carolina

RECENT POWER DEVELOPMENT AT NIAGARA FALLS, by A. R. Urquhart, student. Joint meeting with A.S.C.E. Branch. Jan. 16. Att. 64.

VIBRATIONS IN ELECTRICAL CONDUCTORS, by W. G. Lancaster, Jr., student; THE ELECTRIC EYE NOW ENTERS INDUSTRY, by S. Litman, student. Jan. 23. Att. 40.

Southern Methodist University

RECENT DEVELOPMENTS IN METERING ELECTRICAL ENERGY, by M. P. Jones; RADIO-CONTROL TRAIN, by J. Walker and Dwight Ramsey; SOUTHWESTERN DISTRICT STUDENT CONVENTION, by R. Porter Lindsley. Joint meeting with Dallas Sec. Inspection trip through station W5YF. Jan. 23. Att. 39.

Syracuse University

FILTER SYSTEMS, by K. B. Smith, student; POWER FACTOR CORRECTION, by Karl Strauss, student. Jan. 10. Att. 23.

ELECTRIFICATION OF RAILROADS, by R. Thompson, student; RADIO KNIFE, by H. C. Wolfe, student. Jan. 17. Att. 23.

Texas A. & M. College

Film—"The Hottest Flame in the World." Jan. 12. Att. 150.

University of Vermont

Inspection of all electrical apparatus used at Mary Fletcher Hospital. Jan. 4. Att. 11.

HIGH-FREQUENCY TRANSATLANTIC RADIO TELEPHONE TRANSMISSION, by C. Still, student. Jan. 11. Att. 9.

Virginia Military Institute

THE ENGINEER'S PLACE IN THE SUN, by Prof. W. E. Freeman, vice-pres., A.I.E.E., Univ. of Kentucky; POWER CABLES UNDER THE COLUMBIA RIVER, by J. W. Horseman, student; HISTORY OF SHORT-WAVE RECEPTION, by R. S. Edmonds, student; A MODEL SHORT WAVE RECEIVER, by R. G. Baldwin, student. Oct. 20. Att. 96.

NEW STYLE TELEPHONE CABLES, by J. H. Carrico; TAPE ARMORED TELEPHONE CABLES, by C. E. Stubbs; THE SCIENTIST AND THE WORLD, by C. H. Peng; DIRECT READING OHMMETER, by I. H. McMann, all students. Nov. 7. Att. 70.

THE LIFE OF LEE DE FOREST, by J. M. Trossbach; POWER TRANSMISSION IN NORTH CAROLINA, by T. M. Emerson; WALLENPAUPACK HYDROELECTRIC PLANT, by E. A. Cockey; ALTERNATING CURRENT ARC WELDING, by C. J. Helms, all students. Nov. 28. Att. 68.

A PUSH-PULL CONDENSER MICROPHONE, by E. L. KOSTAINSEK; THE QUIET POWER HOUSE, by L. M. Kaufman; ENGINEERING FEATURES OF THREE PHASE POWER LOCOMOTIVES, by R. Redding; BLUE PRINTING, by J. M. Williams, all students. Dec. 21. Att. 74.

Virginia Polytechnic Institute

Prof. Claudius Lee, counselor, spoke on Institute activities. Jan. 5. Att. 31.

THE DIESEL ENGINE IN AIR SERVICE, by J. A. M. Maddox, student; THE ELECTRICAL THREE-POINT LANDING, by W. A. Woodward, student. Jan. 12. Att. 35.

University of Virginia

THE TELETYPE, by J. W. Bowles, student. Jan. 17. Att. 18.

University of Washington

GENERAL ELECTRIC TEST LABORATORY, by Prof. A. V. Eastman. Jan. 5. Att. 23.

CABLE, by Wm. Heineck, student; USE OF ORDINARY VACUUM TUBES AS PHOTOCELLS, by Francis Gross, student. Jan. 12. Att. 18.

CLASS B AMPLIFIERS, by T. M. Libby, Pacific Tel. & Tel. Co. Jan. 19. Att. 30.

Worcester Polytechnic Institute

SIGNAL ALARM SYSTEMS, by Mr. Canane, Am. Dist. Telegraph. Jan. 17. Att. 45.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Construction

E.E., tech. grad., 43, married; 9 yr design, engg, steam, hydro-power plants, substations, transmission lines; 4½ yr testing plant operation, maintenance, industrial concern; 5½ yr const. supt. pwr. plants, distribution, transmission lines, 3½ yr project engr, utility holding company. Desires position, utility, industrial concern in engg, operating, construction. Available now. D-1912

ELEC CONSTRUCTION FOREMAN, 32, single, desires work along elec construction and maintenance lines. 14 yr practical experience in the erection, construction, and operation of industrial plants and mines. Last 4 yr in Latin America. Speaks Spanish and German. Willing to travel anywhere. Available immediately. Location immaterial. C-2101

Design and Development

TRANSFORMER DESIGN ENGR, 34, single, W. E. & Mfg. Co. student course; 8 yr experience on development and design of small transformers. References. Available now. Location immaterial. D-1850

E.E., 31, single, 2 yr elec mchy test; 3 yr asst. E.E. design and development of elec apparatus for application in marine work. Desires connection with engg or industrial concern in any capacity requiring engg background or where previous experience is of advantage. References. Location immaterial. Available immediately. C-6526

DESIGN ENGR, B.S. (E.E.), U. of Col. 1929, 25, married. Westinghouse engg school and elec design school; 2 yr design of pwr, distribution, network, and testing transformers with large mfg. co. Desires position with operating co. West preferred. Available immediately. D-1866

MECH. ENGR, long and successful experience in design of industrial and pwr. plants would establish connection as plant engr with industry having construction or betterment and maintenance program or with consulting engr engaged professionally in work of this nature. Married. Location immaterial, prefer southeastern states. Available spring of 1933. D-1862

ENGR, 31, 12 yr Bell System and government plant and field experience on sound picture, radio,

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra three-cent stamp enclosed for forwarding.

and telephone (manual, dial, repeater, and carrier current) systems. Design and development of manual and automatic elec testing equipment. Industrial applications of electron tubes. Available immediately. C-9376

ELEC DESIGN ENGR, grad. Worcester Poly. Inst.; 20 yr experience, design, development of d-c mchy. with 3 leading mfrs. Recently developed axle driven generator used extensively for operation of air conditioning equipment of ry. trains; 5 yr teaching. Desires position, designing engr with elec mfr. or teacher in engg col. B-3318

ELEC ENGR AND DESIGNER, 46, col. grad., 18 yr testing and designing experience with large mfg. companies, mainly on transformers; 18 mos. design and development on resistance welding mchy. Some exec. experience. Available at once. Married. C-8806

ELEC ENGR, univ. grad., long experience on design of equipment layouts and control circuits and vector diagram analysis. Desires position where this experience may be applied in the development of new or improved devices or circuits. Present location east, other locations acceptable. B-1923

Executives

COL. GRAD., B.S. in E.E., 36, married. Desires position where a varied knowledge and training in the elec engg field will be of value. Associated 12 yr (past 6 as asst. to elec supt.) with a mining co. operating in So. Am. Experience includes operation, maintenance, testing, etc. References. D-1848

TECH. GRAD., 39, married. Desires position with operation co. or large industrial concern; $11^1/_2$ yr experience in the utility field in engg, construction, maintenance and operation of overhead distribution and transmission; $1^1/_2$ yr test floor, 2 yr electrician and transformer assembly. Available immediately. B-9248

ELEC ENGR, Cornell grad. 1917, 14 yr utility experience, transmission, distribution, hydro plant design, system planning studies, reports, budget control. Available at once. D-1893

PWR. PLANT SUPT; extensive experience steam plant operation, maintenance and betterment work. Broad combustion experience with stokers, pulverized coal, oil and natural gas. Recently with large utility holding company on plant betterment work including starting and testing of new plants and extensions using steam pressures from 350 to 1,450 lb. A-5506

ELEC ENGR, 35, married; 13 yr experience light, heat and pwr. either residential or industrial. Considerable foreign experience hospital needs. X-Ray, physical therapy and electro-medical apparatus. Several languages. Capable executive capacity large scope. Consider anything. Available at once. Any location. C-6892-301-C-4-San Francisco

E.E. GRAD., 43, in genl. consulting work 23 yr. Broad experience in design, investigation, reports, patents and process development. N. Y. State professional engr's license. Experience in elec, mech., civil, and chemical fields, including pwr. plants, waste heat, natural and artificial gas. Best references. Available at once. D-1851

CHIEF ELEC ENGR, 37, grad. E.E., McGill, extensive experience, charge design, construction, operation, maintenance of plant and substations, transmission, trolley, telephone lines; maintenance elec rolling stock, steam train ltg, elec drive, lighting equip. of factories, shops, offices, etc. Record of rapid advancement. Good organizer. Speaks Spanish. Has school grounding in French. C-9557

GRAD. ENGR, 31, desires position as mgr. of small utility or distribution engr; 10 yr varied utility experience includes supervisory design and construction of low voltage a-c networks, urban, rural, and industrial electrification, rehabilitation of generating plants and substations, standardization of distribution construction and operation, estimates, budgetary control and valuation. B-6934

GRAD. E.E., 33, married, $4^1/_2$ yr pwr. plant supervision, operation and maintenance, $3^1/_2$ yr elec transmission and distribution supervision, operation and maintenance, 4 yr telephone engg and plant dept. experience. Middle West location preferred. Available immediately. D-1934

YOUNG ELEC ENGR, formerly in charge of field office for Federal Radio Commission, desires an opportunity to display his ability as field executive in radio, sound motion pictures, television, or other electronic endeavor. References of high caliber for your consideration. Available now. Any location considered. D-1804

Inspection

GRAD. E.E., 38, single, 6 yr experience factory testing, W. E. & M. Co., E. Pittsburgh, Pa., 1 yr steel co. installing and testing elec equipment; 6 mos. factory inspection of transformers; $2^1/_2$ yr genl. inspection of elec equipment with insurance co. Good reference. Available immediately. Any location. D-1461

Instruction

M.S. in E.E. Johns Hopkins Univ., Univ. of Pennsylvania fellowship holder, married, good health, analytical, 28, 2 yr teaching experience, mathematics, physics, elec engg, 2 yr practical, theoretical experience, long distance telephone transmission New York to San Francisco, Bell Tel. lab. Desires teaching, personnel, research along mathematical-physical lines. Invites correspondence. Excellent references. D-1609

B.S., M.A., 37, 5 yr teaching experience, several yr in radio and research laboratories. Desires college teaching position in electronics, radio engineering or electrical engineering. Available in Fall. C-1087

GRAD. E.E., and M.S. in Physics, 30, married. Three yr teaching E.E. and physics courses in univ., 5 yr research, X-rays; ferromagnetic alloys; high voltage insulation studies. Publications. Desires teaching E.E. or physics. Available summer or next academic year. Location immaterial. D-1616

Junior Engineers

ELEC ENGG GRAD, 1928, single, 1 yr testing dept of pwr. co., 2 yr special apprentice elec ry. 1 yr machine shop experience. Desires position with a lab., utility or mfg. concern. Available immediately. C-9112

B.S. in E.E., 1930, single, 24. Best references. Experience: $1^1/_2$ yr construction, operation, steam plants; $1^1/_2$ yr industrial sales representative N. Y. corp; 6 mos. Westinghouse central station sales student work; 1 yr elec. maintenance; recently night engr refrigeration and ice mfg plant. Will go anywhere. Suited to utility. Available. D-1599

B.S. in E.E., 1932, single, 21. Gained experience in elec instrument plant during cooperative course. Desires any position for experience. Salary secondary. D-1578

GRAD. ELEC ENGR, 25, single. Desire tech. position with a commercial firm. Salary and location open. Have the ability to apply advanced theory to present day problems. Have had considerable military experience and training as an officer. D-997

B.S. in E.E., 1931, Mich. Col. of Min. & Tech. single, 23, Tau Beta Pi. Desires work in any engg field. Experience: 3 months swbd. wiring, 1 mo. ltg. design, 6 mos. surveying and map drawing. Speaks Finnish. Location in north one-half of U.S. preferred. Available at once. D-1650

E.E. GRAD., 1929, married, 25. Six mos. elec, materials testing lab.; $2^1/_2$ yr steam turbine development and testing. Desires position with utility, elec. mfr. or firm of construction engrs. Location desired, East or Middle West. C-9132

E.E. GRAD., 1931, 24, single, desires engg work of any kind. Willing to start at bottom and work up. Had 6 mos. research experience. Wage and location of secondary importance. Available immediately. D-188

E.E. GRAD., M.I.T., S.B., 1931, S.M., 1932, 24, single. Sixteen mos. experience with Edison Elec. Illum. Co. of Boston as a cooperative student. Desires position in pwr. transmission field, but is interested in any position with a reasonable chance for advancement. Location immaterial. References. D-1685

GRAD. E.E., 23, M.S. in E.E., 1932, Purdue Univ., single, 3 mos. experience large utility, desires any E.E. work, experience first consideration. Sigma Xi. Salary and location immaterial. Available at once. D-1899

ELEC ENGR 27, married, B.S., 1928 Ph.D. 1931 from Calif. Inst. of Tech. Thesis, "Study of Electrical Transients in a Vacuum Switch With a Cathode Ray Oscillograph." Two yr experience teaching elec and mech. engg. Available July 1933. Location optional. D-1902-331-C-6-San Francisco

B.S. in E.E., 1932, 26, single. Desires position in elec engg field with opportunity for advancement. Location, eastern U.S. with salary immaterial. Available at once. D-1891

E.E. GRAD., U. of No. Dakota '32, 24, major in pwr. Single, good scholastic record, Sigma Tau, prefer design or drafting; 7 yr elec training; 4 yr business experience. Location and salary immaterial. D-1913

B.S. in E.E., 1932. Honor student. Single and in good health. Very good character and industrious. Desires any kind of engg connection, preferably elec. Very good references. Location immaterial and salary secondary consideration. Used to hard work and available immediately. D-1914

B.S. in E.E., 1932, Case Sch. of Ap. Sci., 24, single. High scholastic record; 4 yr industrial experience. Desires position with opportunity for advancement with utility, engg or mfg. firm. Location immaterial. D-908

B.S. in E.E., 1930. Single, 25; 2 yr experimental and development with elec control. Desires position to work into any elec engg field. Location and salary of secondary importance. Available immediately. D-1925

PURDUE GRAD., 1930, B.S. of E.E., 24, married. Eighteen mos. with utility, physical inventory of transmission and distribution, field engg, drafting experience. 7 summer vacations surveying. Can run transit and level; 1 yr RR. signal dept. Capable, not afraid of hard work. Excellent references. Desires position utility or mfr. Available immediately. D-1924

JUNIOR VALUATION ENGR, M.S. in engg valuation, '32, B.S. in E.E., '30, midwestern state col.; 26, married. One yr experience in responsible position on valuation work. Other engg and business experience. Knowledge of accounting, finance and economics. Desires position with utility, engg or financial organization. Location immaterial. D-1931

E.E. GRAD., B.S., '27, M.S., '31, 1 yr advanced graduate study in above subjects. Two yr transmission exp. with tel. co.; 2 yr research in E.E. Available June 1933. Salary open, location immaterial. References available. D-837

E.E. GRAD., 23, 2 yr in res. dept. of celebrated precision instr. maker. Expd. in fundamental elec meas., methods and apparatus; in app. of electronic devices, etc., $^1/_2$ yr each in acoustical res. and mfg. planning on communication equip. Interested position affording application of this exp. Salary in accord with times. Location immaterial. D-1298

B.S. in E.E., 1932, Iowa St. Col. 25, single. Desires engg work in communication (telephone, radio), but will consider anything. Location immaterial, but prefers Middle West. Available immediately. D-1932

ELEC ENGR, U. of Ill. '31, 26, single. Three yr tech. experience including pwr. and telephone engg, Westinghouse test and experimental work, and experience with temperature control apparatus, fan and shading-ring motor design. Knowledge

of French and German. Location immaterial. D-1936

GRAD. ELEC ENGR, 25, B.S. E. and M.S.E. 4 yr experience with large elec mfr, 1½ yr repairing and service work on all types of elec equip., 2½ yr application engg in both industrial and utility fields. Desires responsible position, modest salary with future. Eastern U.S. D-1937

COLUMBIA GRAD., B.S. (1930), E.E. (1931), M.S. in M.E., 1932. Utility work preferred, but any type of work acceptable. Available at once. Salary secondary. Some substation experience. D-1938

B.S. in E.E., 1932, U. of No. Car., 23, single. Desires E.E. work of any type. Willing, capable. Location immaterial. Available now. D-1933

Maintenance and Operation

E.E. GRAD., 32, married, 4¾ yr in elec engr office of large eastern RR. on pwr. plant drafting and design, investigation of requisitions for new pwr. plant material and inspection of elec and pwr. plant mchy; 4 yr as electrician on Diesel, Diesel-elec and turbo-elec ocean going ships. C-8160

E.E. GRAD., 1925, Ohio State, 33, married. Engg dept. of a large utility, operating maintenance and special investigations. Pwr. plant and substation design and supervisory construction experience with a large contractor; 2 yr teaching. Desires an opportunity to demonstrate ability. Previous employers freely consulted. Available immediately. D-996

SYSTEM OPERATING ENGR (ELEC). Univ. grad., 12 yr practical operating experience, 4 yr in genl engg office. Thoroughly familiar all relay applications including distance; short circuit studies; stability studies; transient and steady state; and all problems connected with system disturbances including latest lightning protective methods. Available. Will consider any offer. C-9291

Production

FACTORY PRODUCTION MGR. with long and successful experience with one of the large mfrs. of elec mchy.; recently connected with prominent utility holding co. on rate cases, appraisals, accounting, and mgmt. problems; competent elec and mech. designer and a first class draftsman. B-7331

Research

RESEARCH OR DEVELOPMENT, B.S. state Col., M.S. M.I.T., 36, married. Nine yr test, research and teaching, 7½ yr Westinghouse, tech. problems, development protective and auxiliary apparatus. Author publications. Experience ultra-violet applications, medical, foods. Desires position, physicist, research, development, instructor advanced E.E. courses, transmission or distribution engr. Available immediately. B-7987

E.E. GRAD., Penn. State, 1932, honors, 22, single. Some experience in short wave receivers. Desires research work in short wave, ultra short wave, photo elec cells, vacuum tubes, etc. Also radio communication at sea. Either foreign or domestic field. Salary secondary. Available now. D-1513

ENGR-MECH. AND ELEC, 43, col. grad. extensive experience operating, designing, building large and small pwr. plants. Unusually broad training and intensely practical disposition. Now specializing, physical metallurgy, M.I.T. Expert, microscope and technical photography. Fine practical research man for medium sized mfg. plant or professor of engg for medium sized col. D-986

ENGG GRAD., 32, 10 yr experience at Westinghouse in development and process work on elec insulation such as micarta, mica, treated papers and fabrics, etc., and insulation and elec design of a-c turbine generators, desires position in research, development, process work or elec design work. Available at once. C-1771

Sales

GRAD. E.E. with a long record in the manufacture and sale of elec mchy. now covering the state of Wisconsin wishes to add on other line that would work in well with present representation. C-7029

E.E. GRAD., Northwestern, 1927, married, 29. Very good reputation and references. Experience in operating and testing depts. and radio interference elimination, utility co. Last 3 yr mech. supt. for mfg. concern in Detroit. Sales contact experience. Location immaterial. Salary secondary to future. D-1840

ENGG SALES EXEC., elec-mech. engr, nonferrous metallurgical knowledge. Post grad. deg.; 4 yr steam, elec RR. experience; 5 yr sales experience, district engr, mfr. wire, insulated cable covering investigation, analysis, sales of overhead, underground transmission conductors, related products. Acquainted utilities, industrials, Ill. to Utah. 32, married. Available reasonable notice. D-1923

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Barnes, James P., 29 Cardinal Ave., Albany, N. Y.
Bell, E. DeWitt, 335 River Road, Bogota, N. J.
Brobson, John F., Detroit Daily Mirror, Detroit, Mich.
Carlsen, O. Grag, 635—72nd St., Bklyn., N. Y.
Davis, George P., 184 S. Grace Ave., Lombard, Ill.
Dovjikov, A., Westinghouse E. & M. Co., P.I.T. Engg. Dept., E. Pittsburgh, Pa.
Feldheim, Fred S., Switchgear Engg. Dept., Genl. Elec Co., Phila., Pa.
Johns, Francis J., Westinghouse Club, Wilkinsburg, Pa.
Kane, Martin P., Box 99, E. Pittsburgh, Pa.
Peck, Theodore A., Box 117, Norwood, Mass.
Pool, Russell P., 209 S. Kenilworth, Oak Park, Ill.
Schlechter, A. H., 103 W. 9th St., Apt. 6, Oklahoma City, Okla.
Schwarz, H. F., c/o Bremer Tully Mfg. Co., Muskegon, Mich.
Smith, Frederic V. M., Texlite Elec Sign Co., 4112 Commerce St., Dallas, Texas.
Talbot, H. L., 3562 Lorne Ave., Montreal, Que., Can.
Thornton, George C., P. O. Box 904, Birmingham, Ala.
Tinkey, Otto G., 1401 Albarado Terrace, Los Angeles, Calif.
Weber, Joe, 705—18th St., N. W., Washington, D. C.
Wiles, Warner M., c/o Intl. Rwy. Co., 855 Main St., Buffalo, N. Y.

Membership

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before March 31, 1933.

Adams, R. F., 1005 N. Limestone St., Lexington, Ky.
Anderson, J. J., 172 Lockwood Ave., New Rochelle, N. Y.
Amon, W. A., 629 Washington Ave., Linden, N. J.
Balombin, J. A., 3439 W. 97th St., Cleveland, O.
Barham, S. A., Kimrey Refrigeration Co., Greensboro, N. C.
Barsun, H. F., Smith Young Tower, San Antonio, Tex.
Behn, E. R., 73 Hemlock St., Bklyn, N. Y.
Berkey, W. E., Westinghouse Elec & Mfg. Co., E. Pittsburgh, Pa.
Best, C. R., Brown-Williamson Tobacco Co., Louisville, Ky.
Bettis, S. LeR., Firestone Serv. Stores, Inc., El Centro, Calif.
Black, R. A., Ohio Brass Co., Mansfield, O.
Bolles, K. R., 116 Morse Ave., Brockton, Mass.
Bozoian, A. M., B. D. Sturtevant Co., Hyde Park, Mass.
Brauninger, M. R., Box 438, Kansas City, Mo.
Burnett, R. E., R. R. 1, Brighton, Col.
Call, E. C., 24 S. Franklin St., Knightstown, Ind.
Carey, J. G., 1384 N. W. 29th Terrace, Miami, Fla.
Claassen, F. S., 304 James St., Teaneck, N. J.
Cuttica, H., N. Y. Edison Co., Bronx, N. Y. City.
Dana, S. W., Carnegie Inst. of Tech., Pittsburgh, Pa.
Danforth, H. A., Jr., 23 Lafayette Park, Lynn, Mass.
Darling, C. W., Jr., 367 Park St., Stoughton, Mass.
De Bellis, A. M. (Member), N. Y. Edison Co., N. Y. City.
deBrabander, C., Continental Paper & Bag Mills Corp., Elizabeth, N. J.
Deninson, J. Z. (Member), 645 West End Ave., N. Y. City.
Derin, H., 732 North Hamlin Ave., Chicago, Ill.
Dohrmann, H. C., 32 Kensington Ave., Jersey City, N. J.
Dunlop, R. J. F., 3739 Hutchison St., Montreal, Can.
Dysart, L. S., 2311 Laurel Avenue, Knoxville, Tenn.
Ellis B., 5733 Darlington Rd., Pittsburgh, Pa.
Elwell, A. D., 11 Triangle St., Amherst, Mass.
Ericzon, F. A., Ill. Elec Pwr. Co., East Peoria.
Euler, W. H., Bklyn. Edison Co., Bklyn., N. Y.
Evans, H., 155 S. Third St., Frackville, Pa.
Evans, S. O., Iowa State Col., Ames Iowa.
Fairchild, E. LaV., 2666 Virginia Park, Detroit, Mich.
Fellman, M. N., Phila. Elec Co., Phila., Pa.
Fergus, J. H., Dartmouth Col., Hanover, N. H.
Fetter, C. H., Electrical Research Products, Inc., N. Y. City.
Fisher, C. C., Fisher & Robbins, Sheridan, Ind.
Fleming, H. C., N. Y. Univ., N. Y. City.
Fredericks, F. W., 39 Westervelt Place, Passaic, N. J.
Friend, A. W., 316 Forest Ave., Morgantown, W. Va.
Fuller, F. L., Stevens Inst. of Tech., Hoboken, N. J.
Gartland, R., Chesapeake & Potomac Tel. Co., Washington, D. C.
Gelbarth, H. L., Savory, Inc., Newark, N. J.
Green, C. F., Gen. Elec Co., Schenectady, N. Y.
Griffith, L. F. (Member), Elec Bond & Share Co., N. Y. City.
Grinevich, J. J., 517 W. Pine St., Mahanoy City, Pa.
Haddad, R. A., 500 Riverside Drive, N. Y. City.
Hall, T. H., Hall & Pearsall, Inc., Wilmington, N. C.
Hannum, J. G., Rural Route 2, Boise, Idaho.
Haviar, M., Jr., 164 So. 9 St., Newark, N. J.
Haynes, H. J., Canton, S. D.
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Hendricks, J. P., 304 W. 14 St., N. Y. City.
Heisch, J. V., Gulf Production Co., Pittsburgh, Pa.
Hiatt, F. C., Bklyn. Edison Co., Inc., Bklyn., N. Y.
Hill, C. C., Champion Fibre Co., Canton, N. C.
Hopkins, L. C., Jr., R. C. A. Radiotron Co., Inc., Harrison, N. J.
Howard, H. F., 508 Second St., Fulton, Ky.
Huebner, W. L., Wever, Iowa.
Huey, J. J., 1822 East Third St., Duluth, Minn.
Hyde, R. A., East Bethel, Vt.
Ikuno, F. M., 537—4th St., Rock Springs, Wyo.
James, G. H., 7 Meikle Ave., Newport, R. I.
Johnson, C. E., Bklyn. Edison Co. Inc., Bklyn., N. Y.
Johnson, L. K., R. F. D. 1, Maysville, Mo.
Kalisher, T., Jr., Standard Shipping Co., N. Y. City.
Kattmann, M. E., 1902 Commonwealth, Houston, Texas.
Katzmaier, J. F., 3743 Locke Ave., Los Angeles, Calif.
Kaufman, M. A., Newellton, La.
Kennedy, D. C., Jr., Appalachian Elec. Pwr. Co., Roanoke, Va.
Klekotka, F. X., c/o A. H. Hoffman, Inc., Landisville, Pa.
Klesath, V. L., 407 W. 2nd St., Rolla, Mo.
Knight, E. M., Alliance Natl. Bank, Alliance, Neb.
Koch, J. S., N. Y. Edison Co., N. Y. City.
Kopple, R. E., Harbeson, Del.
Kyte, W. O., Frigidaire Corp., c/o Carter-Owen, Kansas City, Mo.
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Laner, C. J., Standardizing Lab. of Los Angeles Gas & Elec, Los Angeles, Calif.
Langham, M. L., 1518 Park Ave., Mamaroneck, N. Y.
Larson, L. A., Wash. Surveying & Rating Bureau, Seattle.
Lauridsen, H. I., Holmes Elec Protection Co., N. Y. City.
Lee, E. P., Otis Elevator Co., Cleveland, O.
Lewis, F. W., Box 1441, Carmel, Calif.
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Lott, A. O., Zebulon, Ga.
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Mahaffy, G. N., 12 Bradley St., Warren, Pa.
Mankus, C. T., 416 Himrod St., Bklyn., N. Y.
Marr, C. L., Los Angeles Gas & Elec Corp., Calif.
Marsh, W. E., Montvale, N. J.
Mastropole, A. J., 428 West 163 St., N. Y. City.
McMinn, E. R., 260 W. 10 St., Peru, Ind.
McNally, J. A., c/o Postmaster, San Francisco, Calif.
Meagher, J. J., N. Y. & Q. Elec Lt. & Pwr. Co., Flushing, N. Y.
Meehan, H. W. (Member), Am. Tel. & Tel. Co., N. Y. City.

Mikolic, C. R., 2828 W. Galena St., Milwaukee, Wis.
Miller, E. E., Okla. Bankers Assn., Oklahoma City.
Mins, L. E., 142 Montague St., Bklyn., N. Y.
Mitz, G., 49 Ocean Rd., Allenhurst, N. J.
Morse, S. S., c/o I. R. Morse Shoe Stores, Inc., Lowell, Mass.
Mueller, W. P., Box 125, Sebring, O.
Myers, S. J., Warren Lamp Co., Warren, Pa.
Nelson, H. R., Lionel Corp., N. Y. City.
North, E. C., Long Oil Co., Manhattan, Kan.
O'Leary, C., N. Y. & Q. Elec Lt. & Pwr. Co., Flushing, N. Y.
O'Leary, F. R., Pratt Read & Co., Deep River, Conn.
Pettit, D. LeR., Prophetstown, Ill.
Pollak, J. A., 1047 Cherry, Springfield, Mo.
Pollitt, F. C., Eaton Knitting Co., Ltd., N. Hamilton, Ont., Can.
Porter, R. E., Jr., Ky. Lt. & Pwr. Co., Bowling Green.
Prideaux, C. F., Municipal Lt. & Water Plant, Adrian, Minn.
Racheff, T. N., Zeolite Production, Madison, Wis.
Ragazzini, J. R., 503 W. 124th St., N. Y. City.
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Reiter, P., 171 Talbot Ave., Boston, Mass.
Rider, J. E., 424 Wyoming St., Williamsport, Pa.
Ritter, A. LeG., 402 W. L St., Wilmington, Calif.
Rodgers, A. E., Western Union Tel. Co., Newark, N. J.
Roesch, M. A., Jr., W. V. Pangborne & Co., Inc., Phila., Pa.
Ross, A. LeB., Noranda Mines, Ltd., Noranda, P. Q., Can.
Rossiter, P. D., Oliver, B. C., Canada.
Ruebensaal, N. C., Food Chemistry Corp., Pittsburgh, Pa.
Salaskitz, L. P., Bklyn. Edison Co., Bklyn., N. Y.
Sanderson, H. A., Federal Cartridge Corp., Anoka, Minn.
Schooley, A. H., A. H. S. Lab. Serv., Terril, Iowa.
Sears, C. K., Jefferson Elec Co., Bellwood, Ill.
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Templeton, W., 70 Hillyer St., Orange, N. J.
Tilton, R. G., Otis Elev. Co., Cleveland, Ohio.
Tompkins, A. M., Montevista Apts., 63rd & Oxford Sts., Phila., Pa.
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Turner, D. W., Holton, Kan.
Underwood, L. F., 29 No. Hillside Ave., Chatham, N. J.
Veckarelli, C. A., Foster Fabrics Awning Co., Portchester, N. Y.
Vogan, W. G., 1609 Broad St., Regina, Sask., Can.
Warner, J. C., Holland Furnace Co., Salem, N. J.
Warren, J. W., Box 183, Monte Vista, Colo.
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Williams, W. J., Box 1501, Lincoln, Neb.
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Yenni, W. H., Lewis Inst., Chicago, Ill.
Young, J. E., Mio, Mich.
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Zogby, L. M., Jr., N. Y. Edison Co., N. Y. City.
164 Domestic

Foreign

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Greenwell, R., Pub. Wks. Dept., Bombay, Auckland, N. Z.
Hailey, G. (Member), The Hongkong Elec Co. Ltd., Hongkong, China.
Inocencio, D., La Carlota Sugar Central La Carlota Occidental Negros, Philippine Islands.
Johnstone, A., Metropolitan-Vickers Elec Co., Trafford Park, Manchester, Eng.
Kulasekharan, C. R., Corp. of Madras, Madras, India.
Mathur, B. S., Marwar Elec Supply Co., Jodhpur (Rajputana), India.
Mirikin, I., Palestine Elec Co., Ltd., Tel-Aviv, Palestine.
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Moore, J. A. (Member), Posts & Telegraphs Dept., Penang, Straits Settlements.
Nason, P. E., 50th Observation Squad., Luke Field, T. H.
Skerrett, H. R., 10 Hernandez St., Santurce, Puerto Rico.
Varma, R. D., c/o Siemens-Schuckertwerke, A. U. 2 Berlin, Siemensstadt, Germany.
Webber, W., Cia Mexico de Petrolso El Aguila, Mexico, D. F., Mexico.
17 Foreign

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during January are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

ALLOYS of IRON and MOLYBDENUM. (Alloys of Iron Monograph Series.) By J. L. Gregg. New York & London, McGraw-Hill Book Co., 1932. 507 p., illus.; 9x6 in., cloth, $6.00. As the first of a proposed series of monographs upon ferrous alloys, the Engineering Foundation issues this summary of our knowledge of the molybdenum steels and irons. Based upon exhaustive, critical review of volumes of periodicals and books in many languages, here woven into a connected account in usable form. Valuable bibliography included.

ANALYSIS of ELECTRICAL EQUIPMENT USED in the COPPER and IRON MINES of MICHIGAN. (Mich. Col. of Mining and Tech. Bul., n.s. v. 6, Oct. 1932.) By S. I. Tourshou. Houghton, Mich. 19 p., dia., illus., 11x8 in., paper, gratis. Results of a field study intended to give students of electrical mining a general view of its subject, with as many details as are necessary. Certain controversial questions are discussed, the various classes of equipment are described, and some operating data given. This information is also summarized in tables and drawings.

ATOMIC ENERGY STATES as derived from the analysis of optical spectra. Compiled by R. F. Bacher and S. Goudsmit. New York, McGraw-Hill Book Co., 1932. 562 p., illus., 9x6 in., cloth, $6.00. Presents, in tables, the numerical values of the energy levels of atoms and ions investigated up to the present. It is believed to be complete up to the spring of 1931. In addition, considerable later work is included, and a list of references to work which appeared while the book was being published. The volume is the most complete record available.

ECONOMIC TENDENCIES in the UNITED STATES. By F. C. Mills. N. Y., Natl. Bureau of Economic Research, 1932. 639 p., illus., 9x6 in., cloth, $5.00. A survey of economic tendencies during 1922–29. The tendencies are reviewed in comparison with those prevailing during the period preceding the World War. It continues the general price investigations of the national bureau of economic research and extends the survey published by the committee on recent economic changes. The work presents an immense amount of information upon production, costs, prices, capital, income, etc., carefully analyzed and discussed.

ELECTRICITY and MAGNETISM, theory and applications. By N. E. Gilbert. N. Y., Macmillan Co., 1932. 548 p., illus., 9x6 in., cloth, $4.50. Not intended as an introduction to the principles of electrical engineering nor as an exposition of the mathematical theory. Its aim is to provide for non-technical students a textbook covering the fundamental principles and illustrating them by applications to engineering and to appliances in common use.

ELECTRONICS. By R. G. Hudson. N. Y., John Wiley & Sons, 1932. 135 p., illus., 9x6 in., cloth, $2.00. The evolution of the electronic theory, the constitution of matter, conduction, radiation, photoelectric and thermionic emission, electronic rectifiers, and some applications of electronic devices are discussed in this brief introduction to the subject. As far as possible, mathematical processes are replaced by common words.

INTERPRETATION of the ATOM. By F. Soddy. Lond., John Murray, 1932. 355 p., illus., 9x6 in., cloth, 21s. The first section gives a very full account of the discoveries in radioactivity from Becquerel's original discovery onward. Part 2 deals with the wider application of these discoveries and of the conceptions of quanta, relativity, and wave mechanics, to the chemistry of the atom. The author throughout avoids the use of mathematics.

Die KÄLTEMASCHINEN und IHRE THERMODYNAMISCHEN GRUNDLAGEN. (Sammlung Göschen 1058.) By M. Krause. Berlin & Leipzig, Walter de Gruyter & Co., 1932. 140 p., illus., 6x4 in., cloth, 1.62 rm. A very concise description of refrigerating machines, with an account of the scientific principles involved and of the design of the principal types, is provided in this little textbook.

Memento d'Électrotechnique, vol. 2. MACHINES et APPAREILS ÉLECTRIQUES. By A. Curchod. Paris, Dunod, 1932. 502 p., illus., 8x5 in., cloth, 105 Frs. Second volume of a new handbook of electrical engineering in which a number of specialists have collaborated. Its aim is to present concisely and precisely in convenient form for reference, the scientific and technical information commonly required in practice. This volume is devoted to transformers, generators and motors, converters, rectifiers, controllers, safety devices, etc.

PRINCIPLES of ELECTROMAGNETISM. By E. B. Moullin. Oxford, Eng., Clarendon Press; N. Y., Oxford Univ. Press, 1932. 279 p., illus., 10x6 in., cloth, $4.50. This book treats successively of the elements of magnetism, the second law of thermodynamics, iron in a magnetic field, the equations of electromagnetism and some special problems, and Maxwell's equations and the electromagnetic field, and is based upon the author's lecture course at Cambridge University.

TECHNISCHE KULTURDENKMALE im Auftrag der AGRICOLA-GESELLSCHAFT beim Deutschen Museum. By C. Matschoss and W. Lindner. München, Verlag F. Bruckmann A. G., 1932. 127 p., illus., 12x9 in., cloth, $1.65 (Stechert). Brief essays upon the evolution of engineering, accompanied by a remarkable series of photographs of specimens of early bridges, machines, workshops, etc., which are still in existence in Germany.

THEORY of FUNCTIONS. By E. C. Titchmarsh. Oxford, Clarendon Press; N. Y., Oxford Univ. Press, 1932. 454 p., 9x6 in., cloth, $7.50.—An introduction to various branches of the theory of functions, both real and complex, intended to bridge the gap between the elementary textbooks and the systematic treatises. Among the topics discussed are analytic continuation, power series, integral functions, Dirichlet series, Lebesgue integration and Fourier series.

TIME and MOTION STUDY. By S. M. Lowry, H. B. Maynard and G. J. Stegemerten. 2 ed. N. Y., McGraw-Hill Book Co., 1932. 471 p., illus., 9x6 in., cloth, $5.00. Based upon the experience of the Westinghouse Elec. and Mfg. Co., it is intended to be a textbook and handbook for factory executives and practical men. Organization and supervision of time-study, formula, and wage-payment work in a plant is outlined.

TURBINEN und PUMPEN, Theorie und Praxis. By F. Lawaczeck. Berlin, Julius Springer, 1932. 208 p., illus., 9x6 in., 22.50 rm. For 20 years Dr. Lawaczeck has been actively engaged in the development of the turbo-pump and the propeller turbine, the final result being the turbine that bears his name. This book gives an interesting account of the researches, both theoretical and practical, which were carried out during the period of development, and of the commercial machines that resulted.

Engineering Societies Library

29 West 39th Street, New York, N.Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Industrial Notes

Apex Develops Motor Division.—The Apex Electrical Mfg. Co., Cleveland, O., producers of household appliances, is developing the sales organization of its motor division. The company has manufactured small motors of various types for twelve years, and with new, increased facilities, is now prepared to supply the requirements of users of such motors. J. E. Gregory, appointed sales engineer, for fifteen years was connected with the Domestic Electric Company and the Black & Decker Electric Company.

Subway Escalator Contract to Otis Elevator.—Moving to eliminate the long climbs necessary to reach street level from some of the station platforms of the New Independent Subway System, New York City, the commissioners and engineers of the Board of Transportation and the Board of Estimate have awarded a contract to the Otis Elevator Company calling for sixteen escalators to be installed at stations of the system where the platforms are far below the street level. Under the terms of the contract sixteen of the latest type escalators with a total daily carrying capacity of more than 1,500,000 passengers are to be installed. All the escalators are to be two feet wide, of the cleat step reversible type, and they will have a speed of 90 feet per minute. At each station the escalators can be controlled from the change booths as single units or as a complete unit. Emergency buttons for stopping will be provided for all escalators.

Financing of Plant Improvements.—Announcement has been made of the organization of the Improved Industries Corporation, New York, a private enterprise which will assist medium sized industries in purchasing equipment to modernize and improve the efficiency of their plants. These improvements may be made without any initial expenditure on the part of the customer, as the financing corporation purchases the equipment which remains its property until payment out of savings completely amortizes the cost. The financing organization is stated to be in no way identified with any equipment manufacturer, and to maintain an engineering department which studies the operating methods and costs of the plant before specifying definite equipment to accomplish the desired results. The initial capital is reported to be $1,500,000. Chairman of the corporation is Winston Paul, and president is R. G. Macy, formerly a consulting industrial engineer and vice-president of Westcott and Mapes, Inc., New York.

Superseded General Radio Instruments at Reduced Prices.—The General Radio Co., Cambridge, Mass., manufacturer of radio and electrical laboratory apparatus, announces a reduction in discontinued instruments, which should be of particular interest to school laboratories desirous of making additions to their equipment. Many of these items have been discontinued because of industrial requirements which do not particularly affect the usefulness of the instruments for school work. For example, the type 102 decade-resistance box, while superseded by a new shielded type, is exactly the same as those boxes used by the thousands in school and industrial laboratories. They are suitable for assembly into bridges of various types and adaptable to a large number of experiments. Other items include the type 361-B vacuum-tube bridge; type 413-B beat-frequency oscillator; attenuation networks; output meters; a-c current voltmeters (rectifier type); type 552 attenuator; voltage divider; type 443 mutual conductance meter; type 645 amplifier; types 359-D-G-H transformers and type 238-E condensers. All of these instruments are fully described in Catalog F.

Prize Arc Welding Papers in Book Form.—The prize winning papers submitted in the Second Lincoln Prize Competition have been published in book form, consisting of approximately 450 pages, divided into five sections, as follows: Machinery, Shipbuilding, Buildings, Bridges, Large Containers, Piping and Fittings. The use of arc welded alloys to resist corrosion; the substitution of arc welded steel for aluminum without weight increase; the welding of high tensile steels; structural design for the resistance of earthquake shocks—are a few of the interesting new developments which are discussed. The papers cover the subjects in great detail and are illustrated with hundreds of drawings and photographs. One of the principal points on which the papers in the competition was judged was the savings in costs made by the use of arc welding. Each paper gives actual costs and shows how the savings were effected. $17,500 was awarded by The Lincoln Electric Company in prizes to the winning contestants in the competition. The book is bound in cloth-covered boards and published by The Lincoln Electric Company, Cleveland, Ohio. It is sold for $2.50.

Ferranti Surge Absorbers Now Made in U.S.A.—Ferranti, Inc., New York, has completed arrangements to manufacture surge absorbers in the United States. In the past it has been necessary to import these units, with resulting high selling price and delayed delivery. During the five years of the development of the surge absorber, the Ferranti Company and its associated organizations have carried on many interesting and exhaustive investigations which it is stated have confirmed the theoretical principles behind the operation of the surge absorber. Extensive tests, using the cathode ray oscillograph, have been carried out not only in England but also in the United States and Germany.

Surge absorbers are now manufactured in distinctly different types than in the past and include the type "M," for the protection of meters and small motors up to 600 volts; type "C" for voltages below 2200; type "CC," which resembles the pole type potential transformer, is used for all currents up to 50 amperes and suitable for all voltages up to 15,000 volts. Type "DO" is supplied for all currents above 50 amperes and all voltages up to 33,000; for voltages above this figure the Type "H" absorber is used. The Ferranti organizations have been supplying surge absorbers to all sections of the world for the past five years and it is claimed that not a single Ferranti surge absorber properly applied has failed to give positive protection.

Trade Literature

Motors.—Bulletin 540, 20 pp. Describes the Ideal "Self-Syn" motor, a self-excited, self-synchronizing, self-contained general purpose synchronous motor recently developed by the Ideal Electric & Mfg. Co., Mansfield, O.

Fuse Links.—Bulletin L-20553, 4 pp. Describes the application, characteristics, construction, and operation of low temperature universal fuse links for use on all designs of enclosed primary fuse cutouts. Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Synchronous Motors.—Bulletin GEA-1195A, 4 pp. Describes G-E synchronous motors for driving metal-rolling mills. The largest of this type so far installed is one of 9,000 horsepower. General Electric Co., Schenectady, N. Y.

Mercury Arc Rectifiers.—Bulletin 2158, 4 pp. Describes Allis-Chalmers mercury arc rectifiers with control grids. The application of grids for operation control is a promising recent development in the power rectifier field. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Slow and High-Speed Motors.—Bulletin 125, 8 pp., "Sterling System of Direct Power Application." Describes a line of slow and high-speed motors in which the speed reducing or increasing mechanism is built-in as an integral part of the machine. These motors are made in capacities from $^1/_8$ to 50 hp in a wide variety of types and speeds and are applicable to nearly every industrial requirement. Sterling Electric Motors, Inc., Los Angeles, Calif.

Ceramic Insulating Materials.—Folder, describes Lava, Alsimag, Magnesium Oxide, and Aluminum Oxide for use in the electrical, radio, and numerous other fields. Alsimag and Lava are trade names for ceramic insulating materials of high dielectric strength and extreme heat resisting qualities. When production is geared to large quantities they can be made competitive with much cheaper materials. American Lava Corp., 1431 William St., Chattanooga, Tenn.